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## SPINAL CORDECTOMY IN THE MANAGEMENT OF SPASTIC PARAPLEGIA

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Among the more generally utilized neurosurgical techniques of converting extremities from the spastic to the flaccid state have been anterior rhizotomy,<sup>7</sup> posterior column tractotomy,<sup>10</sup> and the injection of alcohol into the spinal subarachnoid space.<sup>11</sup> Each of these procedures has particular points of advantage, but each also presents certain inherent technical difficulties such as the precise localization of specific nerve roots or the control of chemical diffusion.

Recently MacCarty<sup>6</sup> reported the use of selective spinal corpectomy in the treatment of spastic paraplegia resulting from thoracic spine injuries.

In order to observe the effects of the procedure upon the mass reflex spasms and the spastic state, 2 patients with spastic quadriplegia and 2 patients with spastic paraplegia were subjected to spinal corpectomy. The muscular, metabolic, autonomic, and visceral responses to this procedure are the subject of this report.

### CASE REPORTS

*Case 1.* An 18-year-old male quadriplegic patient was admitted to the hospital October 18, 1954. Five weeks before admission he was injured in a fall from a motor tractor. The patient had been totally quadriplegic since injury.

There were frequent mass flexor spasms of both lower extremities with severe flexion contracture deformities of both upper and lower extremities.

There were multiple, large decubitus ulcerations (fig. 1).

The genitourinary consultants advised and carried out a suprapubic cystostomy 4 weeks following hospital entry.

The decubitus ulcerations did not improve with local wound care or with plastic operations. Orthopedic measures failed to improve the deformity or the spasm.

At the time of our initial examination the patient appeared emaciated. There were frequent, violent, painful spasms of both upper and lower extremities. All extremities had severe flexor-adductor type of deformities. There was loss of all sensory modalities below the 3rd cervical dermatome bilaterally. There was marked diaphoresis of the head and neck, but complete anhidrosis below the level of the clavicle. There were large decubitus ulcers overlying the sacrum, femoral trochanters, and the iliac crest regions. All the deep reflexes were hyperactive. There was sustained ankle and patellar clonus with positive Babinski responses bilaterally. The abdominal reflexes were absent.

The cervical x-rays showed a fracture dislocation of the body of the 3rd cervical vertebra.

The preoperative laboratory studies were as recorded in tables 1, 2, 3, and 4. A testicular biopsy revealed intact seminiferous tubules with only minimal spermatogenesis. A muscle biopsy showed no significant changes in muscular histology. A cystometrogram indicated the bladder to be hypertonic. The bladder capacity was small. The preoperative electromyograms showed marked muscle spasm with hyperirritability of the various muscle groups of both upper and lower extremities.

On January 13, 1957, a dorsolumbar spinal corpectomy was performed. The cord was transected at the 10th dorsal segment, and the distal

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FIG. 1. Case 1. The preoperative spastic contracture deformity of the lower extremities. Note the large decubitus lesion.

TABLE 1  
Preoperative and postoperative hemograms

	Case 1			Case 2		Case 3		Case 4	
	Pre*	Post*		Pre	Post	Pre	Post	Pre	Post
		48 hr.	5 days		48 hr.		48 hr.		48 hr.
Hemoglobin, gm. per 100 cc.....	12.5	11.6	11.2	11.5	11.8	10.6	11.5	11.2	10.8
Hematocrit .....	38	37	36	39	40	32	36	35	34
Circulating eosinophils per cu. mm..	118	87	96	22	12	137	112	144	128

\* Pre = preoperative; post = postoperative.

TABLE 2  
Serum electrolyte values before and after cordectomy

	Case 1			Case 2		Case 4	
	Pre	Post		Pre	Post	Pre	Post
		48 hr.	5 days		48 hr.		48 hr.
Serum sodium, mEq. per L.....	142	143	140	133	130	140	134
Serum potassium, mEq. per L.....	5.4	4.1	4.5	3.8	4.0	4.5	4.3
Serum chlorides, mEq. per L.....	113	107	110	99	96	94	99
Serum calcium, mEq. per L.....	5.5	4.5	4.9	8.5	8.7	3.0	4.8
Serum phosphorus, mEq. per L.....	0.8	1.1	1.2	3.2	2.8	1.8	1.4

cord, conus medullaris, as well as the proximal elements of the cauda equina, were resected *en masse* to the 1st lumbar level.

Following the surgery there has been persistent

complete flaccid paralysis of both lower extremities. There have been no mass flexor spasms (fig. 2).

The microscopic sections of the surgical speci-

TABLE 3  
Urinalysis and urinary chemistry before and after cordectomy

Urinalysis	Case 1		Case 2		Case 3		Case 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Specific gravity	1.014	48 hr. 1.016	1.012	48 hr. 1.014	1.005	48 hr. 1.010	1.003	48 hr. 1.040
Albumin	1+	1+	2+	2+	1+	1+	T	T
Sugar	0	0	0	0	0	0	0	0
Microscopic	10 WBC*/HPF	6 WBC/HPF	15 RBC*/HPF	8 RBC/HPF	60 WBC/HPF	35 WBC/HPF	30 WBC/HPF	18 WBC/HPF
Urinary creatinine, gm. per 24 hr. urine	0.257/2960	0.260/4500	0.224/2750	0.254/2430	0.224/2750	0.224/2750	0.276/2150	0.288/2750
Urinary creatinine, gm. per 24 hr. urine	0.11/2960	0.15/4500	0.11/2750	0.18/2430	0.11/2750	0.11/2750	0.10/2150	0.12/2750

\* WBC/HPF = white blood cells per high power field; RBC/HPF = red blood cells per high power field.

men showed a Wallerian type of degeneration involving all of the descending spinal tracts. The preoperative laboratory studies were repeated on the 2nd and 5th days following surgery. With the exception of a transient rise in serum diastase, circulating eosinophils, and the 17-ketosteroid excretion, there were no significant changes from the preoperative values. The repeat testicular and muscle biopsy 3 and 6 weeks following surgery showed no detectable changes from the preoperative microscopic picture. The postoperative skin temperature studies showed a uniform rise, averaging 1.4°C, in both lower extremities. The cystometrograms following operation showed no significant change from the preoperative response. The postoperative electromyograms revealed a complete loss of muscle tone and of reflex muscular irritability of all muscle groups of both lower extremities (fig. 3).

Following surgery some of the decubitus lesions healed spontaneously. The remaining areas were successfully closed by plastic surgical procedures.

The now flaccid state of the lower extremities permitted his movement into a wheel chair. Further rehabilitation as well as vocational training was then possible.

The patient was discharged to his home 10 months following operation.

*Case 2.* A 60-year-old man was admitted to the hospital March 13, 1957. He had been totally paraplegic for 24 months.

This patient was previously hospitalized in 1954 because of the complaint of paresthesias and weakness of both lower extremities. The clinical findings at that time were entirely subjective. He was discharged from the hospital with the recommendation for continued conservative medical management and observation. One year later he was evaluated at another clinic with similar recommendations.

At the time of our initial examination the patient complained of frequent painful flexor spasms of both lower extremities. There was a moderately severe flexor-adductor type of contracture deformity. There was loss of all modalities of sensation below the 10th dorsal dermatome bilaterally. There was complete anhidrosis below the inguinal level bilaterally. There was constant urinary drainage through an indwelling urethral catheter. All deep reflexes were hyperactive. The abdominal reflexes were absent. There was sustained patellar and ankle clonus bilaterally. There were decubitus lesions overlying the sacrum and the femoral trochanteric regions. A complete myelogram showed no evidence of block. The cerebrospinal fluid analysis was normal. The preoperative laboratory studies were as recorded in tables 1, 2, 3, and 4.

TABLE 4

*Preoperative and postoperative blood chemistry determinations*

	Case 1			Case 2		Case 3		Case 4	
	Pre	Post		Pre	Post	Pre	Post	Pre	Post
		48 hr.	5 days		48 hr.		48 hr.		48 hr.
Plasma protein									
Total, gm. %	7.3	7.6	7.4	6.2	6.4	6.2	6.8	6.6	6.8
Albumin, gm. %	4.3	4.3	4.3	3.6	3.8	3.0	3.8	4.0	4.8
Globulin, gm. %	3.0	3.3	3.1	2.6	2.6	3.2	3.0	2.6	2.0
Blood cholesterol, mg. %	220	186	196	164	168			206	198
Blood diastase (Somogyi units)	166	48	124	25	20	144	88	64	114
Cephalin-cholesterol flocculation (48 hr.)	3+	0	1+	2+	2+			1+	1+
17-Ketosteroid excretion, mg./24 hr.	10.0	13.3	12.6	4.3	7.8			7.4	11.6



FIG. 2. Case 1. The flaccid lower extremities following cordectomy

On March 28, 1957, a dorsolumbar spinal cordectomy was performed. The cord was transected at the 10th dorsal segment, and the distal cord, conus medullaris, as well as the proximal elements of the cauda equina, were resected *en masse* to the level of the 1st lumbar vertebra.

Following surgery there was a total flaccidity of both lower extremities. There were no flexor spasms following operation. The patient was free from any pain in either lower extremity.

The microscopic sections of the surgical specimen showed the lesion to be a vascular hamartoma (angioma racemosum venosum) of the spinal cord.

The laboratory tests done before surgery were repeated two, five, and ten days following opera-

tion. With the exception of a transient rise in the 17-ketosteroid excretion there were no significant changes. There was a slight rise in the skin temperature of all areas of both lower extremities. This averaged 0.8°C over the preoperative levels.

Five days following surgery the patient tolerated movement into a wheel chair. This was his first movement out of bed in 10 months. For the convenience of the patient he was discharged to a hospital near his home 14 days following cordectomy.

*Case 3.* A 62-year-old quadriplegic man was admitted to our service September 1, 1957.

This patient was originally hospitalized May 28, 1954, following a fall from the roof of his home.



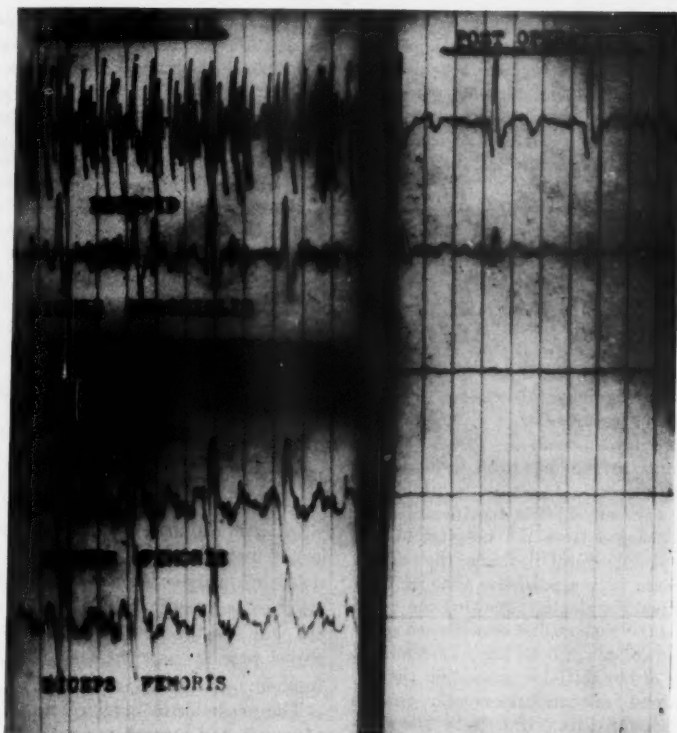


FIG. 3. Case 1. The electromyograms in both upper and lower extremity muscle groups before and after dorsolumbar corpectomy.

He was totally quadriplegic immediately following injury. Cervical x-rays showed a fracture with posterior dislocation of the body of C-5.

Treatment at that time included the use of Crutchfield type of traction and later the use of a cervical collar. A total, flaccid quadriplegia persisted. He was discharged to home care 14 months following admission.

For a period of 7 months before this admission the patient had been confined to bed because of the development of muscular spasticity and flexor type contractions of all the paralyzed muscle groups. There were frequent mass flexor spasms of both lower extremities.

Our initial physical examination revealed a marked flexion-adduction type of contracture of all 4 extremities. There was generalized muscular wasting of all paralyzed muscles. There was total loss of sphincter tone. There was sustained ankle and patellar clonus bilaterally. The Babinski sign was positive bilaterally. There was loss of all sensation below the level of the C-5 dermatome bilaterally. The abdominal reflexes were absent.

There was one large, sacral, decubitus ulcer. An indwelling urinary catheter was under constant drainage.

The preoperative laboratory studies were as recorded in tables 1, 2, 3, and 4. A preoperative cystometrogram showed a hypertonic bladder with small capacity. Electromyograms showed marked muscle spasm with hyperirritability of all muscle groups of both lower extremities.

On September 6, 1957, a dorsolumbar spinal corpectomy was performed. The cord was transected at the 10th dorsal segment, and the distal cord, conus medullaris, as well as the proximal elements of the cauda equina, were resected *en masse* to the 1st lumbar level.

Following corpectomy there was a total flaccidity of both lower extremities. No mass flexor responses could be elicited. The microscopic sections of the surgical specimens showed a Wallerian-type degeneration of all descending fiber tracts of the spinal cord.

The preoperative laboratory studies were repeated 48 hours and 5 days following surgery.

There were no significant changes in any values from the preoperative levels (tables 1, 2, 3, and 4). The postoperative cystometrograms revealed no change from the preoperative bladder response. Following corpectomy the electromyograms showed a complete loss of muscular tone and reflex irritability of all muscle groups of both lower extremities.

The patient was discharged to home care October 31, 1957.

**Case 4.** A 48-year-old woman was admitted to the neurosurgical service November 18, 1957.

At that time the patient gave the history of an abrupt onset of paraplegia with posterior mid-thoracic and bilateral subcostal pain January 19, 1954. There was no history of injury or inflammation. At that time the diagnosis was made of anterior spinal artery thrombosis.

A flaccid paraplegia persisted.

Early attempts at rehabilitation were unsuccessful because of associated emotional problems. This required neuropsychiatric treatment.

She was discharged from the hospital March 26, 1954. Following hospital discharge the patient noted an increase in the muscular tone of both lower extremities. Six months following the onset of the paralysis the patient first experienced painful mass muscle spasms of both lower extremities.

At the time of our initial examination the patient complained of painful muscle spasms involving both lower extremities. Both lower extremities were spastic with slight flexion-adduction contraction. There was loss of all sensation below the D-8 dermatome bilaterally. There was diffuse, symmetrical muscular atrophy of both lower extremities. The deep reflexes were hyperactive throughout. There was bilaterally sustained ankle and patellar clonus. The Babinski sign was positive bilaterally.

This patient had observed the favorable surgical response in cases 1 and 3 reported above. The patient and her physicians requested operation.

The preoperative laboratory studies were as recorded in tables 1, 2, 3, and 4. The cystometrograms revealed the bladder to be hypertonic with small capacity. Electromyograms showed marked muscle spasm with diffuse muscular hyperirritability of all involved muscle groups.

On December 4, 1957, a dorsolumbar spinal corpectomy was performed. The cord was transected at the 10th dorsal segment and the distal cord, conus medullaris, as well as the proximal elements of the cauda equina, were resected *en masse* to the 1st lumbar level.

Following operation there was total flaccidity of all muscle groups of both lower extremities. The patient did, however, continue to complain of bilateral diffuse leg pain.

With the exception of a transient postoperative diabetic-like glucose tolerance curve, and a rise in the blood diastase level on the 2nd postoperative day, there were no significant postoperative changes in laboratory values. The postoperative cystometrograms showed no change from the preoperative bladder response. The postoperative electromyograms showed a loss of muscle tone and of reflex irritability of all muscle groups of both lower extremities. The skin temperature determinations postoperatively showed a uniform increase with an average rise of  $2.3^{\circ}\text{C}$  in both lower extremities.

Because of the patient's complete lack of co-operation, no further rehabilitation procedures were possible.

She was discharged to her home March 7, 1958.

#### DISCUSSION

Each patient in this series has tolerated the surgical procedure without difficulty.

In each instance there has been a complete loss of mass flexor spasms and of muscular spasticity following corpectomy. In each patient the lower extremities have remained flaccid throughout the postoperative period. This duration varies from 24 months (case 1) to 13 months (case 4).

The mechanisms involved in the development of spasm and mass flexor activity are not completely understood (Head,<sup>4</sup> Walshe,<sup>12</sup> Kuhn,<sup>5</sup> and Elkins<sup>3</sup>). Scarff and Pool<sup>10</sup> maintain that these clinical conditions are not only the products of release phenomena, but that "chronic irritation of the cord due to extrinsic or intrinsic scarring of the distal stump at the site of the lesion appears to play an important role." In a separate report Pool<sup>8</sup> has demonstrated that abnormal electrical patterns resembling "convulsive patterns" do arise from isolated portions of the transected spinal cord. These discharges he termed not unlike those associated with cortical epilepsy. Thus, to what extent corpectomy in effect represents the surgical removal of pathways from epileptogenic foci of the central nervous system is of interest to speculate upon. Whatever the causative mechanisms, the spasticity and mass flexor spasms have been relieved following corpectomy. As a result, rehabilitation procedures have been facilitated.

There were no demonstrable persistent metabolic changes following operation. Transient changes in the blood diastase, and the single incidence of a diabetic-like glucose tolerance

curve 48 hours after surgery, were probably related to the "stress" of the surgical operation itself.

In each of our patients the basal metabolic rate was between a  $-10$  and a  $-22$ . There was no postoperative change of significance in this determination. These observations are similar to those of Cooper and associates,<sup>1</sup> who reported on the metabolic alterations in postacute paraplegics. Our patients did differ, however, in that none showed a hypoproteinemia or lowered 17-ketosteroid excretion level.

Each of the patients reported here showed a positive cephalin-cholesterol flocculation test in both preoperative and postoperative determinations. This is somewhat at variance with other reports<sup>2</sup> in that in 5 of 6 cases studied the impaired liver function which usually followed acute spinal cord injury had resolved within 10 weeks after trauma.

In no patient in this series did an automatic, reflex emptying type of bladder develop following spinal cord transection.<sup>9</sup> The cystometrograms showed, in each instance, the bladder to be small with no evidence of reflex contraction. These alterations may be related to the previous bouts of cystitis, or to the previous surgical bladder drainage. Cordectomy produced no measurable change in the cystometrograms.

In each instance there was an increase in the skin temperature of the lower extremities following cordectomy. This increase ranged from  $1.5^{\circ}\text{C}$  to  $3.2^{\circ}\text{C}$ . This increase was diffuse, but most pronounced in the acral portions. We believe that this temperature rise reflected increased skin blood flow. This may have been a factor in the successful postoperative response of the many decubitus lesions.

The patient's psychological improvement following operation has, in most instances, been as striking as the physiological alterations in muscle tone.

The more manageable flaccid extremities following cordectomy have allowed the patient to receive more complete nursing care than was possible with the grotesque bodily attitudes resulting from spastic contractures. Also, the freedom from the fear of a painful flexor spasm did much to improve the patient's existence.

In each instance reported here, following cordectomy the patient was advanced to wheel-

chair life and eventually discharged to home care.

#### SUMMARY

Two cases of traumatic quadriplegia and two cases of paraplegia had dorsolumbar spinal cordectomy performed.

Mass flexor spasms were abolished in all cases and rehabilitation facilitated.

No significant metabolic changes were noted in this series as a result of the surgical procedure.

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## PROBLEMS IN THE MANAGEMENT OF HYPERTHYROIDISM\*

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In this era of potent antithyroid drugs, readily available radioactive isotopes, and competent surgeons, problems in the management of hyperthyroidism have diminished. Each of these therapeutic methods, however, is associated with advantages, limitations, or dangers. It seems timely, therefore, to review these problems that now cover nearly a third of a century.

Anyone who treated patients for thyrotoxicosis before the introduction of thiourea-type compounds rejoices that these drugs are available today. Although there have been fatalities from agranulocytosis because of their use, the reduction in surgical mortality and morbidity far outweighs this danger. The toxicity of all the antithyroid drugs is a problem that is always present and as yet unsolved.

Variations in the frequency with which drug fever, urticaria, skin rashes, arthralgias, nausea and vomiting, granulocytopenia, and agranulocytosis are said to occur<sup>1</sup> depend upon the drug used. One of the authors<sup>2</sup> has had one fatal agranulocytosis while the patient was on propylthiouracil and a nonfatal case with Tapazole therapy. Neo-mercazole (Carbimazole in British reports) became available in 1959 so the number of patients treated is so far insignificant. In a series of well over 800 patients treated during the past 15 years, the frequency of toxic manifestations has been, with propylthiouracil 8.3 per cent, for 1-methyl-2-mercaptoiminazole (Tapazole, Lilly) 6.0 per cent, and for 5-iodo-2-thiouracil, sodium salt (Itrumil, Ciba) 4.6 per cent. All patients have been treated on an outpatient basis, and routine blood counts have not been done. All patients have been cautioned to report immediately any sore throat, skin rash, fever, or joint pain. Parenthetically, a note that the patient has been told of these possibilities should appear on the record. Whenever such complications arise, treatment consists of stopping the drug. The use of antihistamines is indicated for

urticarial reaction, and appropriate antibiotic protection and cortisone support prescribed if granulocytopenia is severe. Although iodide followed by surgery is usually indicated following cessation of the use of the goitrogenic drug, some authors feel that a change in the compound used is justified if the toxic reaction is one of the less severe forms. Thus, Tapazole might be substituted for propylthiouracil if urticarial reactions ensue. Since all of these compounds are associated with toxic possibilities, we prefer to discontinue their use and prepare the patient for surgical intervention.

Today only a few internists and endocrinologists still attempt a definitive cure of toxic diffuse goiter using antithyroid drugs. The vast majority of doctors of medicine in our country today prefer surgical or isotope therapy as the treatment of choice. Our criteria for a successful medical remission by antithyroid drugs are that the patient must remain free from symptoms following cessation of the drug and also be free from thyroid gland enlargement. This latter is most difficult to obtain, but we will not accept as a medical remission a patient who is left with a cosmetically undesirable goiter. In the series of patients considered in this report, 10 to 14 per cent have achieved a cure induced by antithyroid drugs on the terms indicated above.

It is thus obvious that the antithyroid drugs play an important role in the preoperative preparation of patients for surgery. This is their primary objective because their use before treatment with radioactive iodine is not desirable. The choice of which drug to use now assumes some importance once the decision to carry out a thyroidectomy has been made. As long as a patient tolerates the drug, any one of the 4 compounds previously mentioned will bring a patient to the euthyroid state if used in full therapeutic amounts. Three of the drugs require a terminal period of 2 to 3 weeks of iodide administration alone. The fourth, Itrumil, contains iodine, and it can be used right up to the day of

\* From the Radioactive Isotope Laboratory of the Albany Medical Center.

operation without the necessity of adding Lugol's solution as an adjunct. Hyperthyroidism, associated with nodular goiter, is prepared for thyroidectomy in the same manner.

In our experience, Itrumil has produced better involution, less friability, less vascularity, and a smoother postoperative convalescence than have the other drugs. Studies on the height of the thyroid gland acinar cells show the closest return to normal when Itrumil has been the drug used. Clinical experience at the operating table has indicated the superiority of this compound in the other categories suggested in this paragraph. More complete details on this study are to be reported at the Fourth International Goiter Conference next summer. While one of the authors (J. C. M.) has used the other drugs, the advantages of Itrumil, including its lower rate of toxicity and the absence of any case of agranulocytosis during its use, give peace of mind that the other drugs do not.

We have just suggested that the use of anti-thyroid compounds before treatment with the radioactive isotope of iodine is undesirable. Here again, experience was our teacher. Contrary to the report of Elgee and Williams,<sup>3</sup> we feel that more predictable results are secured if the patient receives primarily I-131 than those attained when the isotope is given to a patient made euthyroid or partially controlled by goitrogenic compounds. It is true that patients who are severely ill from thyrotoxicosis should be treated cautiously, but the majority who are eligible for radioactive iodine will have a better end result if no goitrogen is given.

The selection of patients to be treated by a radioactive isotope varies considerably across our country. Some clinics will treat all patients with I-131 who suffer from toxic diffuse goiter. Conservative therapists restrict the use of this isotope to those patients who are over 40 years of age or to those who have had a previous thyroidectomy. Evidence<sup>4</sup> is accumulating to suggest that not even tracer doses should be given to those under 20 years of age. We are aware of 2 cases<sup>5, 6</sup> of thyroid cancer which appeared after treatment of exophthalmic goiter with I-131 in young children.

Determination of the dose to be administered is still largely a matter of guesswork. In our clinic we endeavor to deliver 80  $\mu$ c. per gm. of estimated gland weight allowing a compensatory

factor for the percentage of the I-131 24-hr. uptake. One of the difficulties of this method is that the variations in estimation of gland weight are notoriously unreliable. In a survey, McClintock once examined a series of 140 youths to determine the presence of enlarged thyroid glands. In the double blind technique about 40 of these children were sent through the line a second time, and he disagreed with his own estimation in 20 per cent.

This human variation in the determination of gland size by palpation is why there are many methods of using I-131 therapy. Multiple small doses or a large single dose are described. We have found that a single small dose, 3 to 5 mc., yields better results than any of the others. No one has yet been able to determine clinically the histologic variations in a given thyroid gland which we feel lead to such wide divergence of long-term results. That the results with radioactive iodine are practically as good as those obtained by surgery, no one will deny. Proper selection of patients to avoid the possible carcinogenic activity of radiation and the conservative estimates of the dose to be given do afford the suitable patient a satisfactory remission in his disease. For the exceptional patient with nodular goiter, hyperthyroidism, and complications that would make surgery too hazardous, the dose should be higher, in the region of 20 mc. Many problems remain to be solved in order to bring this method of therapy to a peak of perfection. Radioactive iodine will always be contraindicated during pregnancy, in severe renal disease, and for nodular goiter except in most unusual circumstances, as just indicated.

Surgical resection of the hyperplastic thyroid gland by experienced surgeons still offers the patient a high rate of curability with a low mortality and morbidity. There should be no mortality from the procedure of thyroidectomy except for unpredictable cardiovascular or cerebrovascular accidents. Morbidity can be reduced to zero if the surgeon observes principles that are based upon careful anatomical dissection of the gland. Such careful resections are predicated upon adequate preoperative control of hyperthyroidism by one of the antithyroid drugs with terminal iodide therapy if indicated. One lesson to be learned, however, is that when Itrumil has been used, the amount of thyroid gland to be resected must be less than with other compounds. Because it produces better involution, more



thyroid tissue should be left *in situ*, a 50 per cent resection as opposed to removal of  $\frac{2}{3}$  or  $\frac{3}{4}$  of the gland.

A patient who fails to respond in the predicted manner to an adequate dose of antithyroid drug may not be following the physician's advice. Failure to control the disease adequately on an outpatient basis has been discovered to be due, in many instances, to the patient's refusal to carry out instructions. Forgetting to take the drug, refusing to carry out the necessary program of adequate rest and proper diet eventually come to light as reasons for the apparent drug failure. For such uncooperative patients, hospitalization with continuation of the drug plus intravenous iodide and controlled rest will bring the most recalcitrant individual to a euthyroid level in which it is safe to operate.

Problems that exist because of complicating diseases, such as diabetes mellitus, cardiac decompensation, or auricular fibrillation, are handled simultaneously with the usual therapeutic methods as indicated. As the thyrotoxicosis is controlled the management of an associated problem becomes easier. It is for this group especially that the team of internist, cardiologist, endocrinologist, radiotherapist, and surgeon combines to give the patient the maximum opportunity for restoration of health.

Hyperthyroidism appearing in children is rare but calls for more skillful handling than in the adult. Prolonged antithyroid therapy or surgical resection after proper preparation are the only two safe methods of treatment. Long-term, good results can be obtained.<sup>7</sup>

Pregnancy may precipitate the manifestations of overactivity by the thyroid gland. Control of the disease can usually be accomplished with antithyroid drug and iodide. Itrumul has proven an excellent drug for this purpose. Hypothyroidism in the mother must be avoided because it can result in hypertrophy of the fetal thyroid with hypothyroidism in the fetus. The use of exogenous thyroid hormone in conjunction with a reduced amount of the antithyroid drug should keep the mother at a high euthyroid state. Protein-bound iodine (PBI) values are elevated during pregnancy so that 8 to 12  $\mu$ g. per cent cannot be considered unusual.

If thyroidectomy is carried out during preg-

nancy, a modified resection, leaving slightly more gland *in situ*, is desirable. Operation is postponed until after the 4th mo. if possible. Should antithyroid drug be continued into the postpartum period, the mother cannot nurse her baby. Transmission of these compounds in the milk can easily produce hypothyroidism and permanent damage in the infant.

Thyroid storm is a problem that should never be encountered. Intravenous iodide, with adequate intravenous fluids, heavy sedation, ice packs, oxygen, vitamins, especially the B group, and hydrocortisone help the intensive special nursing care necessary to restore these patients to normal. Antithyroid drugs may be started, but their action is too slow to be relied upon during the acute problem.

#### SUMMARY

1. Competent management of hyperthyroidism entails the selection of the therapeutic method best suited to each individual patient.
2. Itrumul is the antithyroid drug preferred for preoperative preparation of patients.
3. We feel that it is better to avoid the use of goitrogenic compounds if radioactive iodine is to be the definitive treatment.

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## ONE-STAGE ILEOSTOMY AND TOTAL COLOPROCTECTOMY FOR ULCERATIVE COLITIS

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There appears to be an increase in the severe form of ulcerative colitis in this area. In some of these cases surgery becomes necessary for eradication of the disease or as a life-saving measure. During the past 25 years developments in anesthesia, antibacterials, electrolyte and fluid replacement, blood administration, and refinements in surgical technique have reduced the mortality and morbidity associated with surgery in the disease.<sup>8</sup> Where there is universal involvement of the colon and rectum, and in the surgeon's judgment the patient can withstand the procedure, one-stage ileostomy with total colectomy is the procedure of choice.<sup>3, 9</sup>

Indications for surgery (table 1) arise when chronic or fulminating disease and bleeding do not respond to good medical management. Perforation of the colon, obstruction, intra-abdominal or rectal fistula formation, development of pseudopolyps or actual polyps, malignancy, and severe mental depression are further definite indications for surgery.<sup>3, 6, 8, 9</sup>

When surgery has been decided upon and the feasibility of the one-stage procedure is anticipated, careful preoperative preparation becomes important (table 2). Insertion of a Miller-Abbott tube to the 4-foot mark permits intestinal decompression, and by the plication of the small intestine on the tube, decreases its bulk at operation. Whenever possible, intestinal sepsis should be produced with an enteric antibiotic. A nonresidue diet is preferable as in other colonic surgery. The presence of the long intestinal tube in the small intestine does not preclude the diet or oral medication, since suction upon the tube is not necessary after it has passed the duodenum, unless obstruction is present. Electrolyte, fluid, protein, and blood replacement is carried out as indicated. If the patient has been on recent corticotropin or corticosteroid therapy, these should be continued in the immediate preoperative period and gradually withdrawn in the postoperative period. There should be at least 2 L.

of blood available in the operating room. A retention catheter should be placed into the patient's bladder before he is taken to the operating theater.

For the operation (table 3), the patient is placed in the supine position with the knees flexed and the feet taped to a cut-out extension on the operating table so that the position will not have to be changed or the patient moved for the perineal portion of the operation. It is well to be fortified with a cut-down for the intravenous therapy which is necessary during surgery rather than to depend upon needles in the veins, which may become blocked or may slip out at most inopportune times. A well lubricated, large-bore rectal tube should be placed high into the rectum for later use in decompressing the thinned out, friable colon. The place for the ileostomy ring is then marked out on the abdomen, so located that it will not later impinge upon any bony prominences. A long left paramedian incision gives adequate exposure. After gentle exploration a very important step is to empty the gas and liquid from the friable, thinned out, dilated colon, through the previously placed rectal tube. This will markedly reduce the possibility of perforation and spillage when handling the diseased colon. The transverse colon is mobilized first, then the right colon, the left colon, and finally the splenic flexure are freed, carefully avoiding the ureters as the vessels are divided. The abdominal portion of the abdominoperineal resection is then completed as far as possible, staying close to the rectal wall unless carcinoma is present. By staying close to the rectal wall, especially in males, impotence and sterility are avoided. A 1-in. wafer of skin and peritoneum is then excised in the center of the previously marked ileostomy ring location. The ileum is divided above disease and the proximal cut end brought out through the split muscle in this place. About 2 in. of ileum is brought through and the ileostomy fashioned either by the Brooke<sup>2</sup> or Turnbull method<sup>10-12</sup> resulting in a 1-in. protrusion of the ileostomy stoma. In the former,

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TABLE 1

*Indications for surgery*

1. Chronic or fulminating disease unresponsive to therapy.
2. Uncontrolled hemorrhage.
3. Perforation.
4. Obstruction.
5. Fistula formation, intraabdominal or rectal.
6. Pseudopolyp or polyp formation.
7. Malignant disease.
8. Mental depression.

TABLE 2

*Preoperative preparation*

1. Miller-Abbott tube to 4-ft. mark.
2. Enteric antibiotic.
3. Nonresidue diet.
4. Correct electrolytes, fluids, proteins, anemia.
5. Order 2 l. of blood to be available in the operating room.
6. Retention catheter in bladder.

TABLE 3

*The operation*

1. Combined abdominoperineal position on operating table.
2. Cut-down for intravenous therapy.
3. Insert rectal tube.
4. Mark location for ileostomy ring.
5. Incision (left paramedian).
6. "Milk out" colon.
7. Free transverse, then right, left and splenic flexure of colon.
8. Excise 1-in. wafer of skin and peritoneum.
9. Fashion ileostomy (Turnbull or Brooke type).
10. Suture ileal mesentery to abdominal wall.
11. Suture ileal mucosa to skin.
12. Complete perineal excision, close levators, drain.
13. Close abdomen.
14. Apply ileostomy ring and bag in the operating room.

the ileum is turned back upon itself and the mucosa sutured to the skin, while in the latter the musculoserosal layer is removed, and then the mucosal layer turned back and sutured to the skin. Thus, by not exposing any serosa, serositis of the exposed loop, with resulting ileus and electrolyte loss which used to accompany the older types of ileostomy, is prevented. Also,

TABLE 4

*Postoperative care*

1. Antibiotics.
2. Nasointestinal tube suction and intravenous fluids 5 days.
3. Remove perineal drains 3 to 6 days postoperatively.
4. Remove bladder catheter in 24 hr.
5. Teach care of ileostomy.
6. Q.T., 10 Arlington St., Boston, Mass.

stricture of the stoma is minimized with these types of ileostomy. The mesentery of the distal intraabdominal loop is sutured to the anterior parietal peritoneum, being careful to avoid injury to the blood supply of the ileum. Thus, loops of bowel are prevented from being caught between the distal ileum and the abdominal wall postoperatively. The perineal excision is meanwhile completed, either by the first assistant or by another surgical team. The levators may be approximated and the perineal wound drained. Finally, the abdomen is closed. The ileostomy ring and plastic bag\* are applied in the operating room.

During the postoperative period (table 4) it is well to protect these patients with broad spectrum antibiotics. Suction on the long intestinal tube and intravenous homeostasis are maintained until the ileostomy is functioning, usually 3 to 5 days. The perineal drains or packing are gradually removed during the 3rd to 6th days. The retention bladder catheter is usually removed in 24 hr. The attending nurse, and finally the patient are taught the care of the ileostomy and when discharged from the hospital, the patient is encouraged to join Q.T. Inc., an organization for patients with ileostomy and colostomy stomas.<sup>7</sup>

The complications (table 5) following surgery of this magnitude seem to be less than those encountered with less curative procedures.<sup>8</sup> The mortality is variously reported as from 2 to 4 per cent.<sup>6, 9</sup> With the Brooke and Turnbull types of ileostomy, fluid and electrolyte loss is minimal. Peritonitis may occur, especially if there has been preoperative perforation or spillage at surgery, and should respond to the usual means. Ileus may persist beyond the expected period of 3 to 5 days and is usually secondary to peritonitis or the irritation from the large raw surfaces. This should

\* Manufactured by the Tarbot Company, Providence, Rhode Island.

respond to tube suction. Small intestinal obstruction is a threat but should be minimized by adequate suture of the distal ileal loop mesentery to the anterior abdominal wall up to the stoma. This also minimizes the threat of stomal retraction. Stomal fistula and stricture are minimized by the above types of ileostomy. The ring of the prosthesis must be of adequate size, and so placed as not to press upon the protruding stoma. As the edema of the stoma subsides, rings with smaller internal opening diameters are employed for the prosthesis. A very common, minor, but plaguing complication is delayed perineal wound healing.

#### CASE REPORTS

Four cases are presented in which the one-stage ileostomy and total colectomy are employed.

*Case 1.* F. S., a 23-year-old white woman, born in Tennessee, had the onset of abdominal cramping and diarrhea with blood and mucus in the stools in 1953. In 1954 a diagnosis of ulcerative colitis was established. She developed perianal fistulas and marked depression, lost considerable weight, and had amenorrhea. She had been hospitalized for prolonged periods on several occasions, responded to corticosteroid and corticotropin therapy well at first, but with less effect subsequently. She was admitted to the St. Joseph Hospital on Sept. 8, 1956.

She had fever, weighed 92 pounds, was nervous and depressed. She was having about 12 stools daily. The skin and sclera were pale. There were several rectocutaneous fistulas draining mucoid material. The vaginal orifice and anal area were indurated and inflamed. The abdomen was scaphoid and tender.

There was mild albuminuria and ketonuria and the hematocrit was 34. The electrolyte pattern was normal. Barium enema had shown involvement of the entire colon and sigmoidoscopic examination revealed rectal involvement.

The patient was given blood to correct the anemia and was otherwise prepared as described

above. On September 11, 1956, the described procedure was performed. In this case the distal 25 cm. of ileum was grossly involved in the disease, so it was removed with the specimen, the ileum being transected at a normal level as verified by the pathologist examination at the time of surgery. The Turnbull type ileostomy was used in this case.

The entire specimen, including the removed ileum was involved in the ulcerative process (fig. 1). No tuberculosis or malignancy was found.

The postoperative course was uneventful. On September 22 she was discharged from the hospital weighing 83 pounds and taking care of the ileostomy herself (fig. 2). One month later she weighed 98 pounds, and her mental outlook was excellent. The ileostomy was functioning well (fig. 3). In November she weighed 113 pounds, she was menstruating again and the perineum was healed.

However, in December 1957 she developed inflammation of the ileostomy stoma. She was put on corticotropin and got along fairly well until January 2, 1959, when she developed fever, anorexia, and a tender mass in the lower abdomen. Her weight dropped back to 98 pounds. She was hospitalized and an abdominal abscess drained on January 7, 1959. *Escherichia coli aerogenes*, sensitive to Furadantin, was cultured from the pus. Methylene blue given by mouth came through the drainage wound, establishing that there was an enterocutaneous fistula. She refused surgery at that time, so she was discharged from the hospital



FIG. 1. Case 1. Specimen removed at surgery

TABLE 5  
Complications

1. Mortality 2 to 4 per cent.
2. Fluid, electrolyte loss.
3. Peritonitis.
4. Ileus, obstruction.
5. Ileostomy fistula, stricture, retraction.
6. Delayed perineal wound healing.



FIG. 2. Appearance of plastic ileostomy bag in place.



FIG. 3. Appearance of ileostomy stoma one month after operation.

and re-admitted February 4, 1959. Anemia which was present was corrected with blood and on February 7, after successful intubation of the small intestine with a Miller-Abbott tube, operated upon. There was a gastrojejuno-cutaneous fistula which was resected. The stomach was repaired, the loop of jejuno-ileum involved in

disease was removed and continuity was re-established by end-to-end anastomosis. The distal ileum and ileostomy were resected and a Brooke type ileostomy established this time.

The specimens were reported as being involved in ulcerative enteritis with fistula formation. Because the patient had been on corticotropin therapy before surgery, this was continued postoperatively. Again the postoperative course was uneventful, and on February 17, 1959, she was discharged from the hospital, healed, eating, and with the ileostomy functioning well. When last heard from December 25, 1959, she was in good spirits, remaining well, but on corticotropin therapy.

*Case 2.* M. C., a 43-year-old white woman born in Tennessee, began to have diarrhea and abdominal cramps in 1942. In 1944 she became seriously ill, a diagnosis of ulcerative colitis was established and she required 10 weeks' hospitalization during which time she was given transfusions because of blood loss in the stools. In 1951, and again in 1956 she was hospitalized for prolonged periods. During the last admission she was placed on corticotropin therapy which she continued to take. In spite of excellent medical management she again began to have diarrhea, pain, and weight loss. Her menses had ceased in 1955. She was admitted to the St. Joseph Hospital on November 13, 1956.

At this time the patient had low grade fever. She was nervous and depressed. The abdomen was tender, and there were marked external and internal hemorrhoids. Her weight was 99 pounds. Her hair was falling out (adrenocorticotrophic hormone, ACTH effect?).

Barium studies showed the typical pipe-like colon. Sigmoidoscopy revealed marked rectal involvement by the disease. There was a leukocytosis. The electrolyte pattern was essentially normal.

Preparation and operation were performed as described above. A Turnbull type of ileostomy was fashioned in this instance.

The removed specimen showed universal ulceration with pseudopolyp formation in some areas. No tuberculosis or malignancy was found (fig. 4).

The postoperative course was entirely uneventful, and she was discharged from the hospital on November 28, 1956, with the abdominal incision healed, weighing 98 pounds, and caring for the ileostomy herself. The corticotropin therapy had been withdrawn. In February 1957 her hair, which had fallen out in handfuls while she was on corticotropin therapy, began to grow back well, her menses had returned, she became cheerful, and she weighed 121 pounds. In December 1957 she married a childhood sweetheart. It was not



FIG. 4. Case 2. Specimen removed at surgery

until December 1958 that the perineal wound finally healed. At present she works efficiently as a doctor's office assistant.

**Case 3.** A. H., a 42-year-old white man, born in Louisiana, was troubled with abdominal distention, cramping, diarrhea, and fever for 3 years, when in February 1956, during a moderate attack, a diagnosis of ulcerative colitis was established by sigmoidoscopic examination, although barium studies of the colon were equivocal. The presence of a left-sided colon was the only positive x-ray finding. He was treated conservatively and appeared to do well, but on April 18, 1956, was hospitalized, critically ill with a fulminating exacerbation of the diarrhea and peritonitis. He finally responded to corticotropin, antibiotics, long-tube intestinal decompression, and electrolyte replacement. After recovery barium studies, as before, were equivocal, and sigmoidoscopy was negative. In July 1956 he had an appendectomy, and a type II malrotation of the mid-gut was confirmed.

On about October 3, 1956, he again developed diarrhea. A week later a perianal abscess developed and on October 17, 1956, he was admitted to the St. Joseph Hospital, markedly distressed, thin, and with a doughy, tender abdomen. There was a

right perirectal abscess. The abscess was drained. Laboratory studies showed no azotemia. The blood chlorides and potassium were normal. There was a moderate alkalosis. The serum proteins were low normal.

He rapidly became worse in spite of large doses of corticotropin, low residue intake, antibiotics, fluid and electrolyte replacement therapy. He became disoriented. The abdomen became more distended, with rebound tenderness throughout. The diarrhea was marked. On October 20, 1956, because he was becoming worse under therapy, it was decided to operate upon him before he deteriorated beyond relief.

He was prepared as outlined above. At operation October 23, 1956, it was found that the colon had perforated in several areas. There were about 1000 cc. of blood-colored, foul, fecal fluid in the peritoneal cavity. The common, unattached mesentery for the large and small intestine comprising the midgut area was foreshortened and indurated. In spite of the marked peritonitis the total colectomy and ileostomy was performed as a life-saving measure. During the procedure 2 L. of blood and 200 mg. of Solu-Cortef were given intravenously. The Turnbull type ileostomy was fashioned in this instance. The specimen showed universal confluent ulceration throughout with multiple perforations (fig. 5).

Postoperatively he did fairly well considering the findings at surgery. He developed a superficial abdominal wound infection with *pseudomonas aeruginosa* and *E. coli aerogenes*, sensitive to novobiocin. The infection responded slowly to



FIG. 5. Case 3. Specimen removed at surgery



this antibiotic. He rejected all of the silk sutures which had been placed in the rectus sheath. On December 7, 1956, he was discharged from the hospital weighing 101 pounds. By April 1957 the perineum healed. His outlook on life was much improved and he obtained a better position than he had before his illness. He remains well, weighs 150 pounds, and has no difficulty with the ileostomy.

*Case 4.* J. H., a 20-year-old white boy, born in Louisville, Kentucky, had suffered with attacks of abdominal cramping, fever, and bloody diarrhea for 1½ years. He had been hospitalized for prolonged periods, several times with critical illness, responding less each time to corticotropin and corticosteroid therapy. He became depressed and had marked personality changes. About October 1, 1957, he had an exacerbation and rapidly lost about 35 pounds. When he was admitted to the St. Joseph Hospital on October 11, 1957, he was placed on excellent medical management and large doses of corticotropin but did not respond well.

On October 17, 1957, his temperature was 100, pulse 120, there was abdominal distention and generalized abdominal tenderness.

Barium enema showed pseudopolypoid changes throughout the colon (fig. 6). Sigmoidoscopic

examination revealed rectal ulceration and inflammation. Cultures of the stool for ameba and dysentery bacilli were negative. There was a trace of albumin in the urine, the hematocrit was 35.5, and there was a marked leukocytosis. The electrolyte pattern was normal.

Because of poor response to the medical regimen, the polypoid changes, and mental changes, surgery was decided upon. Preparation as outlined above was started October 22, 1957. The corticotropin was continued. On October 24 one-stage ileostomy and colectectomy was performed. The Brooke type of ileostomy was used in this case. At operation there was obvious peritonitis with a sigmoid perforation. During surgery he received 1500 cc. of blood and 200 mg. of hydrocortisone.

The specimen showed universal ulceration with marked pseudopolyp formation (fig. 7).

While in the recovery room he became violent as he was coming out of anesthesia, had to be restrained, and suffered an upper brachial plexus paralysis. On November 2, 1957 the abdominal wound dehiscd and a secondary closure was done. On November 13 the abdominal wound was healed and physiotherapy was started for the left upper extremity. On November 23, 1957, he was discharged from the hospital with his parents caring



FIG. 6. *Case 4.* Appearance of barium-filled colon, showing the pseudopolyposis.

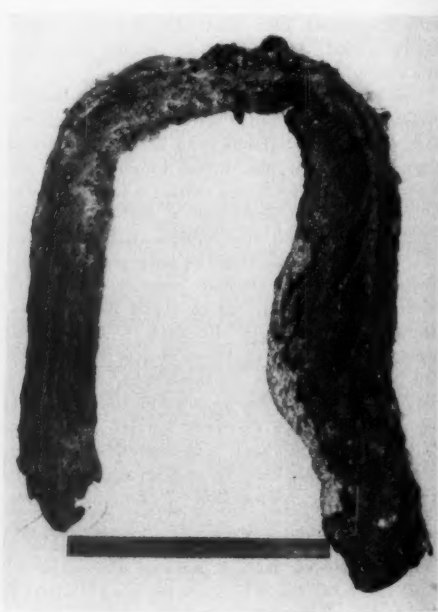


FIG. 7. *Case 4.* Specimen removed at surgery



for the ileostomy, weighing 125 pounds, to receive physiotherapy on an ambulatory basis. By January 1958 the function of the left arm and shoulder recovered, he weighed 166 pounds, and he was taking care of the ileostomy himself. By February 1959 he was mentally excellent, had begun to play basketball and golf, and was working. In February 1960 he still had a 1-cm. area of unhealed perineal wound, but he weighed 195 pounds, was in excellent general health and when not working was indulging in strenuous sport including water-skiing behind a flying hydroplane.

#### COMMENTS

It is not intended to advocate total colectomy and ileostomy in one stage as the only method of surgical treatment of ulcerative colitis.<sup>1</sup> However, when surgery does become necessary and the rectum is involved in the disease, as it usually is, and when the patient can withstand the procedure, then the one-stage procedure would seem to be preferable. The morbidity incidental to retained diseased bowel with lesser procedures, and the risk of multiple procedures, and anesthesia administrations are usually avoided.<sup>3-5</sup> The saving in time and money is not to be minimized.

It is indeed gratifying to see how well these patients tolerate the procedure, and when they recover, not only is it a physical recovery, but a mental one as well.

The newer types of ileostomy, such as the Turnbull and Brooke, have contributed a great deal in reducing, to a tolerable minimum, the postoperative loss of electrolytes and fluids. Some authors indicate that it is no longer necessary to dilate the ileostomy when fashioned in the manner described,<sup>2, 10</sup> but the patients in this report have inserted the gloved finger daily, when changing the disposable plastic bag. The plastic bags are inexpensive and since they are disposed, odor is no problem.

The only prolonged complication noted has been delayed healing of the perineal wound which is probably due to the previous perianal and perirectal inflammation.

The patients reported have joined Q.T., Inc. As members of this organization they become acquainted with others, throughout the country, with ileostomies. They receive literature pertinent to problems of ileostomy care and can share their problems.<sup>7</sup> Often these patients make contributions and report them. Of the above patients,

case 4 has modified the plastic ring of the prosthesis so that bag replacement is made easier, and case 3 has added a pocket to his undershorts, in which the ileostomy bag can rest, thus reducing the strain on the ring and abdomen.

#### SUMMARY

1. When surgery becomes necessary in ulcerative colitis and the rectum is involved in the disease process, total colectomy with ileostomy in one stage can serve as a life-saving and curative procedure.

2. Four cases in which this procedure was performed are presented. The only prolonged complication has been delayed healing of the perineal wound.

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## TRAUMATIC DIAPHRAGMATIC HERNIA\*

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While the recent surgical literature indicates that diaphragmatic hernia due to violence is increasing in frequency, such hernias are rare in the average hospital practice. Numerous reports<sup>2, 14, 18</sup> attest to this rarity. Carlson and his associates<sup>3</sup> reviewed the English literature from 1946 through 1957 and found only 99 cases of diaphragmatic hernia due to nonpenetrating trauma. In 1957, Moreaux<sup>15</sup> collected from the world literature 349 diaphragmatic ruptures from severe thoracoabdominal trauma. Most other reports, with the notable exception of Bernatz and his associates,<sup>1</sup> contain a few cases only, indicating the difficulty for one surgeon or group of surgeons to amass any great experience in the management of this problem. This inexperience seems reflected in the results in various series, both in the delay of diagnosis and in morbidity and mortality.

Recent personal experiences with diaphragmatic hernia following trauma have emphasized the complexity of the problems in the diagnosis and treatment of this condition and prompted us to review our cases. Since 1950, 10 patients with diaphragmatic hernia following various types of trauma have been treated surgically either on the charity surgical services of the Confederate Memorial Hospital or among the authors' private patients. The details of these cases are analyzed in table 1, and their review is the basis of this report.

Five cases (table 1) were acutely injured patients whose hernias were discovered early, and immediate repairs were carried out. Four of these hernias followed nonpenetrating injury while one resulted from a penetrating wound. The other 5 cases (table 2) developed hernias which were discovered and repaired from 4 months to 20 years after the initial injury. Two of the hernias followed penetrating injuries and 3, blunt trauma.

\* From the Departments of General and Thoracic Surgery, Highland Clinic and Confederate Memorial Medical Center, Shreveport, Louisiana. Presented at the New Orleans Assembly of the Southeastern Surgical Congress, March 21 to 24, 1960.

There were no hernias which resulted from surgical incision of the diaphragm and none from its inflammatory necrosis.

### CLINICAL FEATURES

Clinical reports show traumatic diaphragmatic hernia to be primarily a condition of the young adult male. This was true in this series where the 10 patients included 9 males and 1 female; their average age was 34.1 years. These hernias occur predominantly on the left side because the liver affords some protection to the right diaphragm. The rarity of hernias on the right is emphasized by Harrington's series<sup>10</sup> where only 1 right-sided hernia was found in 58 cases and by Neal's report<sup>16</sup> in 1953 when a review of the American literature yielded only 10 right hernias. Recently, more comprehensive reviews<sup>1, 3, 9, 11, 15</sup> indicate that the true incidence of traumatic hernia through the right diaphragm approximates 13 per cent. There were 2 ruptures of the right diaphragm in this series and both contained the liver, or a portion thereof.

The symptomatology of patients with traumatic diaphragmatic hernias may be extremely varied. It is dependent upon a number of factors which include the time interval between trauma and diagnosis, organs involved in the hernia and the status of their blood supply, size of the diaphragmatic rupture and the volume of contents within the hernia, and the associated injuries. Carter and associates<sup>4, 5</sup> have emphasized that diaphragmatic hernia is usually recognized in one of 3 phases and that the symptoms vary accordingly. The first of these is immediately after trauma. This is a stage when the symptoms are not specific and usually relate to associated injuries. Pain at the site of injury and shock predominate in the clinical picture. In the 5 patients reported here whose hernias were treated in the early phase, all showed evidence of shock. One had an open chest wound, 1 other complained of pain in the chest at the site of trauma, and another complained only of leg pain from a compound fracture. No history was ob-

TABLE 1  
Summary of patients treated by early or immediate repair

Patient Date of Admission	Age, Sex	Type and Mode of Injury	Associated Injuries	Symptoms and Physical Findings	X-ray Findings	Location and Contents of Hernia	Operation	Results
1. W. N. L. 4-13-52	50 F	Penetrating, struck by auto.	Fractures, left femur, right clavicle, left 6th, 7th, 8th ribs, lacerated spleen.	Of associated injuries. Marked dyspnea due to open left chest wound.	No x-rays of chest.	Large rent, left diaphragm, spleen herniated.	Transthoracic repair with 2 layers of cotton sutures. Splenectomy.	Convalescence uneventful. Discharged 4-25-52.
2. J. R. M. 11-9-52	17 M	Nonpenetrating, auto accident.	Fractures, left ilium, multiple ribs, lacerated spleen.	Pain left chest; shock. Paradoxical respiration due to multiple rib fractures, left chest.	Air-containing organ left chest; nasogastric tube inserted to prove it stomach.	Long tear, entire circumference left diaphragm; spleen, stomach, colon herniated.	Transthoracic repair with 2 layers of silk sutures. Splenectomy.	Convalescence uneventful. Discharged 11-22-52.
3. W. M. 7-6-53	20 M	Nonpenetrating, truck accident.	Fractured pelvis, lacerated spleen.	Semicomatose; shock, dullness left lower chest with peristaltic sounds. Abdominal tenderness.	Gastric bubble in left hemithorax. Confirmed by lipiodol studies through gastric tube.	4-in. rent, medial left diaphragm. Stomach, colon, spleen, left lobe of liver herniated.	Transthoracic repair with 2 layers of cotton sutures. Splenectomy.	Convalescence prolonged due to pelvis fracture. Discharged 8-13-53.
4. R. B. 4-6-57	26 M	Nonpenetrating, auto accident.	Head injury, liver laceration.	Mental confusion; shock. Abrasion right chest wall. Diminished breath sounds right thorax. Abdominal tenderness.	Elevation right diaphragm with clouding right hemithorax. Fluoroscopy showed round smooth shadow which moved with respiration.	Large defect with right diaphragm torn from anterior costal attachment, liver herniated.	Abdominotherapeutic repair with 1 layer of silk.	Convalescence uneventful. Discharged 4-16-57.
5. J. C. 4-26-59	40 M	Nonpenetrating, auto accident.	Compound fractures, left tibia and fibula, lacerated spleen.	Pain left leg; shock. Absent breath sounds left chest; tender abdomen.	Mediastinal shift to right with gastric bubble overlying lower $\frac{2}{3}$ chest.	7-cm. tear, left diaphragm, anterior and lateral to esophagus, spleen, stomach, colon herniated.	Transabdominal repair with 1 layer of silk sutures. Splenectomy.	Died 3rd post-operative day due to fat embolism.

TABLE 2  
Summary of patients treated by delayed repair

Patient, Date of Admission	Age, Sex	Type and Mode of Injury	Associated Injuries	Symptoms and Physical Findings	X-ray Findings	Interval from Injury to Operation	Location and Contents of Hernia	Operation	Results
6. J. S. 5-11-50	56 M	Penetrating gunshot wound left chest.	None.	Intermittent left shoulder pain. Exam within normal limits.	Homogeneous density with rounded borders occupying left costophrenic angle. Fluoroscopy: density anterior and inseparable from diaphragm. Elevation left diaphragm with air-containing shadows at or above level of diaphragm.	Several years.	2-cm. defect, left anterior diaphragm. Omentum only herniated.	Transthoracic repair by plastication utilizing cotton sutures.	Convalescence uneventful. Discharged 6-6-50.
7. J. W. 2-6-58	28 M	Penetrating knife wound left lower chest.	None.	Of complete colon obstruction.		2 yr.	6 by 8-cm. defect, left posterior diaphragm. Omentum, left transverse colon incarcerated.	Transabdominal repair with silk sutures.	Postoperative wound dehiscence. Corrected and discharged 3-5-58.
8. H. T. 10-10-53	30 M	Nonpenetrating, auto accident.	Multiple left rib fractures.	Nausea, dyspnea, pain in left chest and abdomen. Peristalsis present left lower chest.	Large air bubble overlying left lower thorax with heart displaced to right. GI Series: Stomach and colon in lower chest.	3 mo.	Large defect, left anterolateral diaphragm. Spleen, stomach, transverse colon, omentum herniated.	Transthoracic repair with cotton sutures.	Convalescence uneventful. Discharged 11-3-53.

9. P. B. 9-13-55	46 M	Nonpenetrating, right chest crushed by machinery.	Fractures right forearm, multiple ribs.	Pain lower chest and upper abdomen. Diminished breath sounds, lung right base.	Rounded, soft tissue mass protruding into base of right lung field. Inseparable from diaphragm on fluoroscopy.	4 mo.	8-cm. defect, right medial phragm. Portion of right lobe liver herniated.	Transthoracic repair by pliation of diaphragm utilizing silk sutures.	Convalescence uneventful. Discharged 9-22-55.
10. W. S. 10-2-57	28 M	Nonpenetrating, hit by truck, left chest crushed.	Unknown if any.	Of complete colon obstruction with strangulation	Left hemithorax opaque with heart shifted to right. After thoracentesis yielded dark bloody, fecal smelling fluid, multiple fluid levels in left chest.	20 yr.	4-cm. defect, left phragm. 8-in. transverse colon incarcerated and gangrenous.	Transthoracic repair with silk sutures after resection of gangrenous colon and extirpation of colonic stomata on upper abdomen.	Developed postoperative bowel obstruction requiring lysis of adhesions and left empyema. Re-covered and colostomy closed December 1957.

tained from 2 patients because of their state of consciousness.

In the second or interval phase, patients may be entirely asymptomatic or symptoms may be related to the gastrointestinal, pulmonary, or circulatory systems. These may include nausea, vomiting, dyspnea, cyanosis, tachycardia, restlessness, and pain. The pain may be substernal, epigastric, thoracic, or referred to the shoulder regions, and it may be relieved by vomiting or gastric aspiration. Three patients in this series were treated during this phase. One, with a small left diaphragmatic rent from a knife wound, complained only of intermittent left shoulder pain. A 2nd patient whose hernia developed after blunt left chest trauma, had left lower chest and upper abdominal pain. This was accompanied by nausea and difficult breathing. The 3rd patient had pain in the right lower chest and upper abdomen associated with respiratory wheezing.

The third phase in which these patients appear is that of intestinal obstruction or strangulation. Many of the second group will progress into this stage if untreated. The time interval between injury and strangulation will vary, but in one series,<sup>5</sup> 85 per cent of cases with strangulation occurred within 3 years. These symptoms include severe upper abdominal or lower thoracic cramps, nausea, vomiting, and obstipation. Hemorrhage may occur from an incarcerated or strangulated hollow viscus. Symptoms referable to the pulmonary or vascular systems may also occur in this stage. Two patients here reported were seen with typical symptoms of intestinal obstruction. One, following knife trauma 2 years before, had incarceration of the transverse colon without strangulation, while the second, whose hernia followed blunt trauma 20 years before, had incarcerated transverse colon which had become gangrenous.

Physical findings in patients with traumatic diaphragmatic hernia may show great variation.<sup>5, 6</sup> In acute injuries, the findings may be primarily those of shock and associated injuries. Examination of the chest may reveal evidence of penetrating or blunt trauma and decreased breath sounds, decreased expansion, or dullness, and mediastinal or cardiac shift may be noted. The finding that is extremely important is that of peristaltic sounds in the thorax or succussion splash. The 10 patients in this report had varied findings. Five patients with acute injuries were

in shock, but findings in 2 of these were sufficient in themselves to establish the correct diagnosis. These included an open chest wound and peristaltic sounds in the chest. In 5 patients who were seen in a subsequent stage, 1 had bowel sounds present in the left chest with a shift of the heart to the right, 2 had rales or decreased breath sounds at the lung base, 1 had signs of intestinal obstruction with normal chest findings and 1 had no abnormal findings.

#### DIAGNOSIS

The diagnosis of diaphragmatic hernia due to trauma may be obvious, but it is frequently quite difficult to make. In acute injuries, one should keep the possibility of ruptured diaphragm in mind, and in this way, herniation through such a rupture can be recognized early. There are 3 types of injuries which should immediately arouse one's suspicion. These are (1) crushing injuries to the chest, particularly those with multiple rib fractures of the lower chest, (2) non-penetrating trauma to the abdomen with associated fractures of the lumbar spine or pelvis, (3) gunshot or knife wounds of the lower chest or upper abdomen.

In those patients who develop symptoms from traumatic diaphragmatic hernias a prolonged interval after the initial injury, a history of an injury of these types may be the most important diagnostic lead available. If the interval has been prolonged, it frequently takes leading questions to elicit such information.

Roentgenographic examination is usually most helpful in establishing a definite diagnosis in these patients. The significant findings have been noted by numerous authors<sup>4, 5, 12, 13</sup> but need emphasis. These include (1) an apparently high-lying diaphragm, (2) an air bubble or homogeneous density above the anticipated diaphragmatic level, (3) a shift of the heart and mediastinum to the right, especially with a left chest injury, (4) areas of atelectasis of the lung above an arch-like shadow, and (5) unexplained density in left lung base having appearance of pneumonitis but without evidence of resolution on serial x-rays.

Once the diagnosis is suggested, it can usually be confirmed by fluoroscopy. This examination should show decrease or absence of normal respiratory movement of an apparent high diaphragm which is actually the superior border



of the herniated viscus. One must be aware of movement of the herniated viscus which will simulate diaphragmatic motion. If portions of the gastrointestinal tract are involved in the hernia, barium by mouth or enema should substantiate the diagnosis. It may be expedient in the acute injuries to pass an opaque gastric tube or to administer a small amount of radiopaque material by gastric tube to establish the location of the stomach. The importance of adequate x-ray study and obtaining films of good quality even in the acutely injured patient cannot be overemphasized.

Even these procedures do not always clarify the diagnosis. If the hernia is made up only of omentum or liver, the diagnosis cannot be confirmed by barium study. This type of hernia is seen as a spherical mass inseparable from the diaphragm in any projection. Air studies such as pneumothorax or pneumoperitoneum may be helpful in these cases, and they may also help differentiate hernia from eventration. Occasionally, surgical exploration may be necessary to establish the correct diagnosis.

Pleural fluid at the lung bases may simulate or mask a diaphragmatic hernia. If the fluid is free, a recumbent film will show the fluid distributed over the entire hemithorax and the diaphragm in its true position. Thoracentesis may be necessary; the fluid accompanying a diaphragmatic hernia is usually bloody or serosanguinous. Dark foul smelling fluid usually accompanies a strangulated hernia, but intestinal contents may be obtained.

The cases herein reported well illustrate the methods of diagnosis and the problems that may be encountered. In case 1, the diagnosis was apparent on inspection of an open chest wound. Three patients (cases 2, 3, and 5) with acute rupture of the left diaphragm presented classical physical findings of absent breath sounds and/or peristaltic sounds in the left chest. X-ray examination showed the gastric bubble in the left lower chest, and diagnosis was confirmed by passing a nasogastric tube and/or Lipiodol administration (fig. 1). Case 4 showed a high-lying right diaphragm following blunt chest trauma, and a ruptured diaphragm was suspected. On fluoroscopy, the upper border of the liver simulated a normal diaphragm, and the diagnosis was not made immediately. Persistent shock prompted exploration which confirmed complete right diaphragmatic rupture with the liver herniated.

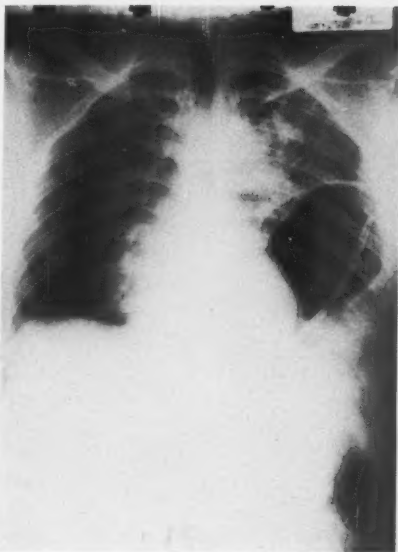


Fig. 1. Acute rupture of left diaphragm with presence of stomach in left chest confirmed by passing nasogastric tube.

Case 6 had a history of an old gunshot wound of the left chest with pain in the left shoulder and a homogeneous density occupying the left costophrenic angle of the chest x-ray. Fluoroscopy showed this to be inseparable from the diaphragm and thoracotomy confirmed the presence of incarcerated omentum in a diaphragmatic rent. In case 7, there was a scar of a healed knife wound over the left posterior chest and x-rays showed an air-containing area at or above the diaphragmatic level with overlying atelectasis (fig. 2). Exploratory laparotomy showed transverse colon incarcerated in a traumatic diaphragmatic hernia. Case 8 represents the classical picture of traumatic diaphragmatic hernia discovered 3 months following blunt trauma. There were peristaltic sounds in the left chest; chest x-ray showed an air bubble in the left thorax with displacement of the heart to the right (fig. 3a). Barium studies demonstrated the stomach in the left chest (fig. 3b).

In case 9, a right hernia was difficult to diagnose because of minimal symptoms and lack of air-containing organs involved. Past history of crushing right chest injury with multiple rib fractures, and a mass above the right diaphragm, which was inseparable from it, suggested the



FIG. 2. Case 7. Chest roentgenogram showing air-containing shadows above the left diaphragmatic level with overlying atelectasis.

diagnosis, and pneumoperitoneum gave additional confirmation (fig. 4). Case 10 illustrates the problem of traumatic hernia with strangulation. This patient had an old chest injury and

presented with obstructive symptoms. The initial chest x-ray (fig. 5a) showed an irregularly contoured, air-containing shadow at the left diaphragmatic level, but its significance was not appreciated. Within 48 hours, a left pleural effusion developed, and thoracentesis yielded dark bloody fluid with a fecal odor. X-ray following this procedure showed multiple fluid levels in the left chest (fig. 5b). Thoracotomy confirmed the presence of a gangrenous transverse colon in the left pleural space.

#### TREATMENT AND RESULTS

It is generally agreed that the treatment of traumatic diaphragmatic hernia is surgical. The optimum time for operation varies with the individual patient. In the patient with an acute injury, surgery usually should be performed as soon as the patient's condition is stabilized or it becomes apparent that his condition cannot be improved further without exploration. Occasionally, in patients with severe associated injuries, conservative measures to decompress the gastrointestinal tract and to expand the lung are indicated to improve the general condition while best priority of treatment is determined. In chronic cases, time of surgical treatment can be

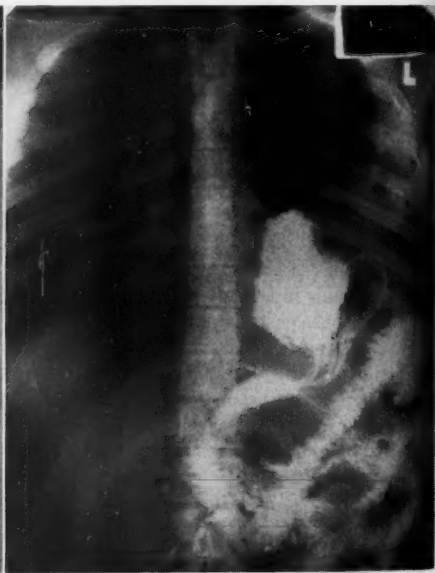
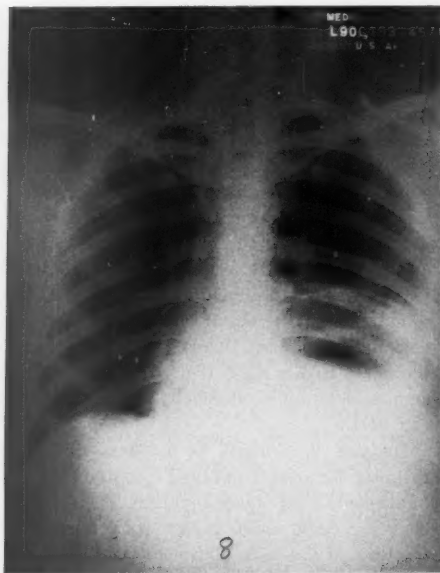


FIG. 3. Case 8. Left. Chest x-ray showing air bubble in left thorax with displacement of heart to the right. Right. Barium study confirms stomach displaced upward into chest.

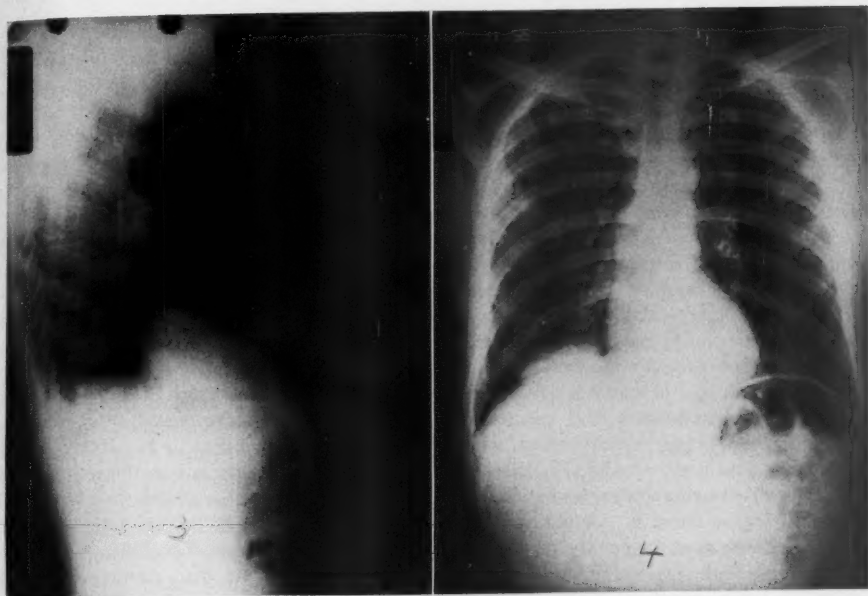


FIG. 4. Case 9. Chest roentgenograms utilizing pneumoperitoneum to visualize liver in traumatic opening in right diaphragm.

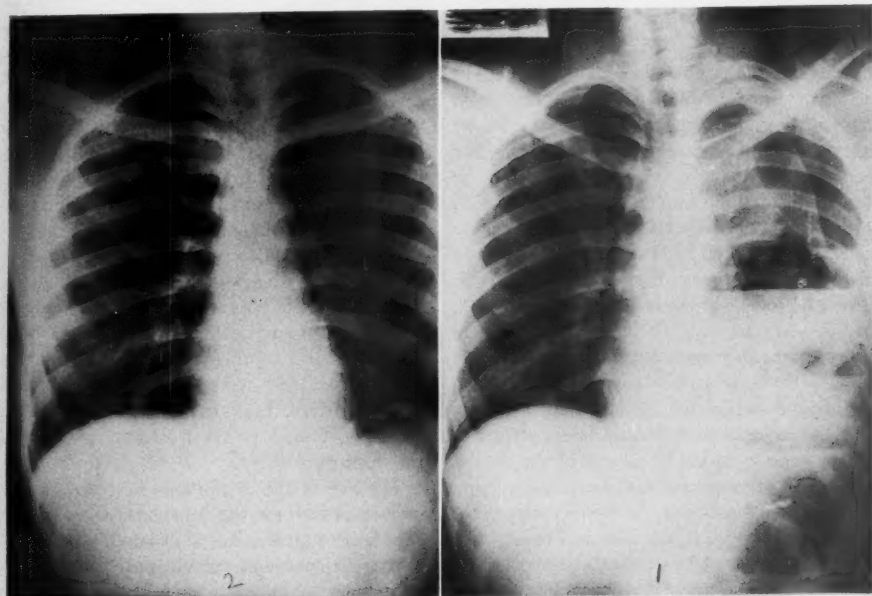


FIG. 5. Case 10. Left. Irregularly contoured, air-containing shadow at left diaphragmatic level represents strangulated transverse colon in traumatic diaphragmatic hernia. Right. Multiple fluid levels seen in left thorax following thoracentesis of apparent left pleural effusion.

elected unless obstruction or strangulation develops, when operation becomes urgent.

The best approach for repair of these hernias is not entirely agreed upon. Most surgeons agree that the rare right-sided ruptures are best treated through a thoracic approach. The majority also favor a similar approach on the left, but this preference is not unanimous. We have favored a thoracic approach for most hernias of this type, but with associated or suspected intraabdominal injury, the approach may be initially abdominal and converted to thoracoabdominal exposure as necessary. Among the 10 cases reported, 7 were repaired through a primary thoracic approach. In 2 others, repair was accomplished through a left upper abdominal incision, and one patient had an initial right upper rectus incision which was converted into a thoracoabdominal incision when a right diaphragmatic rupture was found.

Herniated organs found in our patients were the same as those most frequently reported by other authors<sup>6, 7</sup>—the spleen, stomach, colon, omentum, and small intestine on the left and the liver on the right. Since traumatic hernias have no sacs, the procedure frequently necessitates freeing the abdominal organs from the diaphragm and pleural structures before returning them to the abdominal cavity. Chronic cases of long duration will usually have the greatest number of adhesions. Once reduction is accomplished, closure of the diaphragmatic rent is performed by whatever method seems convenient. For small or uncomplicated defects, simple apposition or imbrication of the diaphragmatic edges with interrupted nonabsorbable sutures is usually satisfactory. It seems advisable when possible to utilize an overlapping type of repair. With avulsion of the diaphragm from the chest wall, it is necessary to reattach it to the intercostal muscles, preferably spanning 1 to 2 interspaces at a higher level. More complicated repairs which have utilized pericardial flaps, partial thoracoplasty, elevation of the perirenal fascia, suture of the liver capsule to the periphery of the defect, or plastic prostheses have not been necessary in our cases. We have not favored crushing the phrenic nerve though it was done in 1 case in this series. Most reports<sup>1, 6, 14</sup> indicate that this has been largely abandoned. Postoperative drainage of the chest has been practiced routinely.

The results of repair of traumatic diaphragmatic hernia have apparently been good. Harrington<sup>10</sup>

reported no recurrences in 58 cases and Grage and associates<sup>9</sup> noted none in their series. There are no known recurrences in the cases here reported.

The reported mortality accompanying these injuries and their repair is not so favorable. Harrington<sup>10</sup> reported 5 deaths in 58 patients with traumatic diaphragmatic hernia, while a more recent report<sup>1</sup> from the Mayo Clinic noted a 3.4 per cent mortality rate in 112 patients. Nine cases with 1 death were reported from the Cincinnati General Hospital<sup>5</sup> and O'Rourke and Jacobson<sup>17</sup> reported 7 patients with diaphragmatic rupture following nonpenetrating trauma with 4 deaths, 3 of which followed operation. Grage and associates<sup>9</sup> reported an over-all mortality rate of 31 per cent in 26 patients but had an operative mortality rate in 19 cases of 5.2 per cent. Carlson and his associates<sup>3</sup> collected 99 cases due to nonpenetrating trauma with an over-all mortality rate of 16 per cent. Moreaux<sup>15</sup> reported 79 collected patients with rupture of the diaphragm operated on with a mortality of 34 per cent. There was 1 death in 10 patients operated on here, and this was due to fat embolism.

A number of factors seem to affect the morbidity and mortality associated with these lesions. Perhaps the most important of these are the severe associated injuries, because deaths may result from these before treatment for diaphragmatic hernia can be carried out. The most frequent of these injuries are multiple rib fractures, visceral injuries, and fractures of the spine and pelvis, though any type of injury may accompany diaphragmatic rupture. Grage and associates<sup>9</sup> noted 54 visceral injuries and fractures in 26 patients, while Moreaux<sup>15</sup> found rib fractures in 26 per cent of his collected series. Twenty-two per cent of the patients in 2 large series<sup>3, 15</sup> had severe visceral injuries associated. Four of our patients had lacerated spleens and another had a lacerated liver. Four patients had multiple rib fractures, 2 had pelvic fractures, and 4 other fractures were noted.

The size of the diaphragmatic tear is another important factor in the outcome of these patients. The large ruptures are associated with massive organ displacement which may alter cardiopulmonary physiology to a hazardous degree. Operative deaths due to cardiac arrest have been reported<sup>15</sup> in 13 patients, and it has been postulated that these may have been due in part to

previous cardiorespiratory disequilibrium. Small diaphragmatic tears are usually not so serious unless associated with incarceration and strangulation of viscera. The occurrence of the latter complications increases both morbidity and mortality in these patients.<sup>4, 19</sup> There were 2 cases with obstruction in this series and one of these had strangulation. Though these patients survived, they both had increased morbidity and a prolonged hospital course.

#### SUMMARY

Ten patients with traumatic diaphragmatic hernia treated since 1950 are reviewed. Three hernias followed penetrating trauma and seven resulted from nonpenetrating injuries. Diaphragmatic rupture and hernia were discovered and treated immediately in five patients, while in the remainder, the treatment was delayed months or years.

The clinical picture of traumatic diaphragmatic hernia is varied. Immediately after trauma, the features are usually those of shock and pain. Later, symptoms relating to gastrointestinal, pulmonary, or circulatory systems may predominate. Physical examination is usually not diagnostic, but evidence of new or old thoracic trauma may be significant, especially when accompanied by peristaltic sounds in the chest.

Early diagnosis is facilitated by a high index of suspicion. Three types of injuries should increase one's suspicion: (1) crushing injury to the chest, particularly when associated with multiple rib fractures of the lower chest, (2) nonpenetrating trauma to the abdomen with associated fractures of the spine or pelvis, and (3) gunshot or knife wounds of the lower chest or upper abdomen. Diagnosis is usually confirmed by roentgenographic examination including fluoroscopy and barium administration. Occasionally, surgical exploration is necessary to establish a correct diagnosis.

Transthoracic repair of these hernias is recommended as soon as the patient's condition permits, and the recurrence rate is low. There was one death in this series but the reported over-all mortality rate is high due to associated injuries and complications such as intestinal obstruction and strangulation.

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## SMOOTH MUSCLE TUMORS OF THE GASTROINTESTINAL TRACT\*

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Smooth muscle tumors of the alimentary tract include both the benign leiomyomas and the malignant leiomyosarcomas. They are not commonly seen but do comprise about 1 per cent of all tumors of the gastrointestinal tract.

Reports of these tumors in the medical literature are numerous; the clinical signs and symptoms are well known or readily predicted. Unfortunately these signs and symptoms are neither peculiar nor unique to these tumors and are therefore not particularly helpful in arriving at a definitive preoperative diagnosis.

Small leiomyomas are found at postmortem examination in a high percentage of cases, when a careful search for them is made. The number of leiomyomas and leiomyosarcomas of the alimentary canal which produce clinical symptoms is small enough, however, that few surgeons gain a wide experience in treating them. Moreover, many of these tumors are bulky, occasionally reaching a truly tremendous size, so that when seen and when the clinical diagnosis is that of carcinoma, a hopeless prognosis may be predicted, and it seems not unlikely that operation may be undertaken hesitantly and possibly refused. With these various thoughts in mind this review is undertaken.

The smooth muscle tumors arise in the muscular layers of the gastrointestinal wall. They are commonly and usually single and well circumscribed although a number of multiple tumors are recorded. Both the benign and malignant forms are firm, often rubbery, and the larger ones lobulated. Their variation in size is remarkable, ranging from less than 5 mm. to 20 and 30 cm. in diameter. They may weigh as much as 6500 gm. Ordinarily the tumors are grossly, sharply circumscribed, but microscopically a definite capsule is seldom seen. The cut surface presents a gray-pink, whorled appearance. In view of the fact that the tumors are relatively avascular, retrogressive and inflammatory changes occur which account for fibrosis, necrosis, cavitation (fig. 1), hemorrhage, abscess formation, calcification, and

cyst formation, and may give a diverse and variable gross picture.

Starting in the muscular coats, rarely in the muscularis mucosa of the gastrointestinal tube, the tumor may grow towards the lumen or away from it, or occasionally in both directions to produce the "hour-glass" form. With the exception of those tumors which arise in the rectum, the mucous membrane commonly becomes ulcerated as the tumor grows.

The histologic picture is much like that of smooth muscle tumors elsewhere in the body. The spindle-shaped cells, resembling the normal muscle cell in great or lesser degree, are usually arranged in interlacing bundles. There is often a striking tendency for the cell nuclei to be aligned in palisade formation. Unlike the smooth muscle tumors of the skin and the uterus, the intestinal tract tumor cells and fibers interdigitate with the uninvolved cells at the periphery, making them appear as infiltrating malignant tumors. This is an unjustifiable criterion, for it occurs most characteristically in the small, asymptomatic, incidental tumors found at operation or necropsy.

The histologic criteria for malignancy have been arrived at with some difficulty. The presence of myofibrils as evidence of cellular differentiation, and their relative absence as stages or degrees of de-differentiation is unreliable; there are some tumors well supplied with myofibrils which are certainly malignant for they metastasize. Cellular size and shape can vary greatly in these tumors, and it is quite possible that in many tumors the formation of bizarre cells is an indication of degeneration rather than of activity. The relative number of mitoses is usually considered an almost infallible indication of growth activity and of relative importance as a criterion of malignancy. If two or more mitoses per high power field are present, one is usually fairly secure in predicting malignancy. However, the converse is not universally true; some clinically malignant tumors show few mitoses.

There are no demonstrable peculiarities of these tumors based on sex, race, or geography. In general, about 60 per cent of them occur in the

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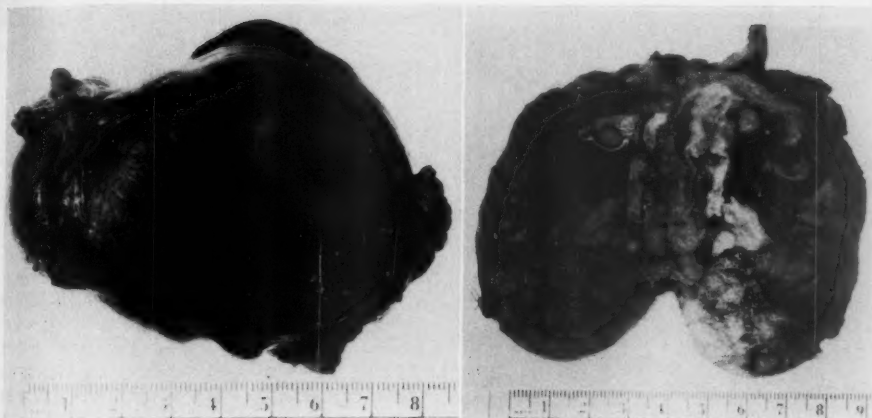


FIG. 1. Leiomyoma stomach showing necrosis and cavitation

ages 40 to 60 years, while 20 per cent occur under these ages and 20 per cent over. By far the most commonly reported site of occurrence is the stomach, followed by the small intestine and then the remainder of the tract in more or less decreasing frequency. In the stomach most tumors occur in the body of the stomach, while the cardia shows a slightly greater incidence than the pylorus; in the colon the vast majority appear in the rectum.

The symptoms which these patients will present will depend largely upon the tubal diameter of that portion of the tract in which the tumor occurs, upon the presence or absence of mucosal ulceration over the tumor eminence, and upon the rate of tumor growth. It is well perhaps to note that upon rare occasion one of the leiomyosarcomas will appear as a highly malignant tumor and will run a fulminating course. This small group of tumors has led some pathologists to suggest that in general, the biologic potential of the malignant smooth muscle tumor is low, and because this is so, to favor the use of the term "malignant leiomyoma" for this group instead of the suffix "sarcoma."

#### ESOPHAGUS

Although the occurrence of benign tumors of the esophagus has been known for many, many years, such tumors are relatively infrequent. The leiomyomas are the most common of these. The relative rarity of muscle wall tumors of the esophagus, as compared to tumors having their origin in the mucosa, is suggested by the studies of Chi and Adams and of Johnson, Clagett, and Mc-

Donald. The former authors found only two cases of leiomyomas of the esophagus at the University of Chicago between 1936 and 1947, while they encountered 246 esophageal cancers during the same period. Johnson and his associates reported a total of 18 leiomyomas and leiomyosarcomas seen at the Mayo Clinic between 1920 and 1949, but during the same interval the diagnosis of carcinoma of the esophagus was made 2312 times. Storey and Adams were able to report upon 114 leiomyomas in 1956.

Lyons and Garlock stated that in 1951 only 6 leiomyosarcomas of the esophagus had been reported. Their report added the seventh case to the literature. It seems very likely that other instances of this tumor are known but are unreported.

The clinical course of the myomas and myosarcomas is usually slowly progressive over a period of many months or years. In the benign lesions it has been recorded for periods up to 20 to 25 years. In the esophagus (fig. 2) these symptoms are mechanical in origin; up to a point the elasticity of esophageal wall compensates for luminal encroachment even in the presence of a moderately large tumor. When the tumor enlarges rapidly or encircles the esophagus the progression of symptoms may be rapid. In order of frequency, these symptoms are dysphagia, retrosternal or retroxiphoid pain or discomfort, and a variety of digestive disturbances such as vomiting, regurgitation, indigestion, belching, nausea, and anorexia. Weight loss undoubtedly follows as these symptoms become more pressing. Secondary



FIG. 2. Leiomyoma of the esophagus

anemia from ulceration of the overlying mucosa may be present, but is seldom of significance when compared in frequency with the anemia which occurs with the gastric muscle tumors.

It has been suggested that there are at least two clinical varieties of leiomyosarcoma of the esophagus: (1) the polypoid, localized neoplasm without metastases, and (2) the invasive tumor infiltrating the esophageal wall, growing in large part extrinsically, and sometimes metastasizing to the regional lymph nodes. An impression is gained from the scanty reports on such tumors that the spindle-celled type of esophageal leiomyosarcoma characterizes the first of these while the mixed cell variety, which infiltrates extensively and may metastasize early, accounts for the characteristics of the second group.

It would seem from reported experience that the only logical therapeutic approach to either the benign or malignant myoma is surgical extirpation. Of the 114 cases of leiomyomata reviewed by Storey and Adams, 60 per cent were treated by simple transpleural enucleation. Perhaps one-fourth required esophagectomy and esophagogastrostomy. A variety of other measures, including local excision, were required for the remainder of patients.

The surgical experience with the leiomyosarcoma group is small. These tumors are reportedly

unresponsive to radiation therapy, and surgical excision is usually advised. The following case report has some bearing upon this matter:

A 62-year-old white man was first seen at the University Hospital in March 1958 with dysphagia of 3 to 4 months duration and an 18-lb. weight loss. The x-rays demonstrated an esophageal lesion in the upper third of the esophagus. A biopsy of this revealed a leiomyosarcoma. Because of the size of the mass 5700 r of high energy irradiation from a cobalt source was given (fig. 3) and completed in May 1958. All dysphagia for well masticated food disappeared and a 12-lb. weight gain occurred. Resection of the residual lesion was done on June 30, 1958. At operation it measured perhaps 2 cm. in diameter, and the mucosa over it was ulcerated. Resection and a right colon interposition operation was done. The patient succumbed on July 9, 1958, from separation of the upper anastomosis, cervical cellulitis, and empyema.

Histologic section of the residual tumor shows a profound radiation response and marked tumor regression. This response is noteworthy in that this group of tumors is characteristically considered resistant to radiation therapy. In this patient, operative resection of the tumor was made possible by the excellent regression in tumor size following such therapy.

#### STOMACH

Gastric leiomyomas are rather frequently encountered at the postmortem table. In contrast to this fact is the relative rarity of such tumors causing symptoms sufficient to bring the patient to a physician. It is probably unprofitable to document the number of cases reported to date in the medical literature. However, in 1938 Collins and Collins searched the available literature for such instances, and probably their comparative figures will stand today. These authors were able to find 1347 benign gastric tumors reported. Leiomyomas comprised 539 (39.9 per cent) of the total number of gastric benign tumors. At the same time 54 cases were recorded of malignant leiomyomas of the stomach. More recently Skandalakis and associates brought the entire number of reported cases of smooth muscle tumors of the stomach to a grand total of 1017. This datum includes both the benign and malignant tumors and dates from their earliest description in 1762. Meissner opined that the majority of benign tumors recorded in statistics came from

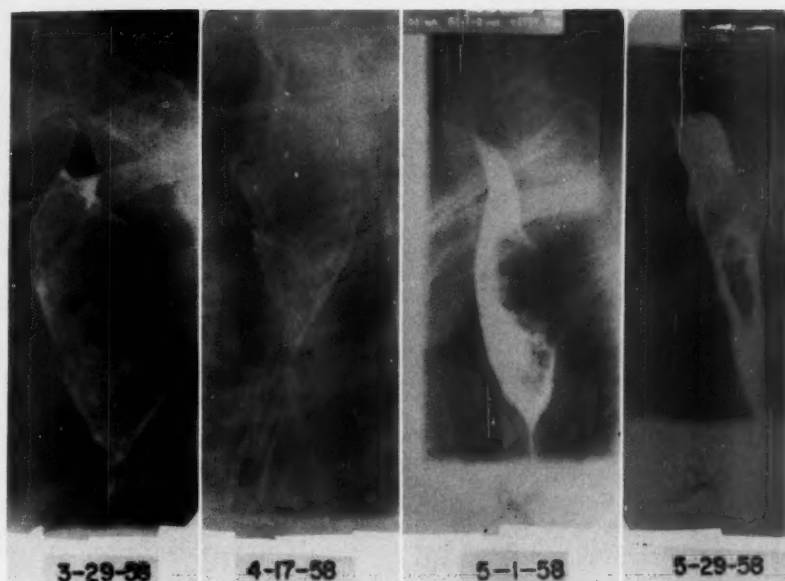


FIG. 3. Leiomyosarcoma esophagus during the course of radiation therapy in the preoperative period

surgical specimens removed by operation. To determine more accurately the true incidence of leiomyoma, the stomachs from 50 autopsies were studied carefully and minutely. Forty-six per cent of these adult stomachs contained leiomyomata. Quite in contrast to these figures are those of many other authors whose systematic studies of necropsy material have failed to show any such incidence, or one approximating it. Undoubtedly, this difference stems in large part from the interest of the prosector and the minuteness of the examination conducted.

It is now rather generally believed that the malignant leiomyomas or leiomyosarcomas may well originate in a previously existing leiomyoma, although there is a paucity of reports of transitional forms. Of speculative interest is the question of why more such malignant lesions do not occur—this question is of particular interest if almost 50 per cent of stomachs contain leiomyomata.

The gastric leiomyomas and myosarcomas may occur anywhere in the stomach, but are most common in the pars media and antrum, involving both curvatures and either gastric wall. In about 10 per cent of instances they are multiple; one patient is reported to have had 14 separate gastric

leiomyomas. The largest number are submucous, often pedunculated, and commonly lobulated.

The symptoms and signs which such a patient presents relate more to size and location than to benignancy or malignancy. The most common is gastrointestinal bleeding, either hematemesis, melena, or unexplained anemia. Often there is vague upper abdominal discomfort possibly due to and often diagnosed as peptic ulceration. Pyloric obstruction, and upper abdominal mass or the acute abdomen due to perforation of the tumor, and even obstruction from an extramural tumor may occur, in diminishing frequency. In a few instances achlorhydria has been reported.

Preoperative diagnosis, when possible, is usually based upon proper interpretation of the roentgen films (fig. 4) or upon gastroscopic appearance. Many leiomyomas show microscopic calcification, but gross calcification visible on ordinary abdominal roentgenograms is unusual. In general, the roentgen diagnostic criteria of the benign tumors are:

1. Tumor filling defect, circumscribed (and punched out in appearance when ulcerated).
2. The filling defect, usually on the gastric walls, leaving the curvature regular and pliant.
3. Rugae surrounding the tumor more nearly

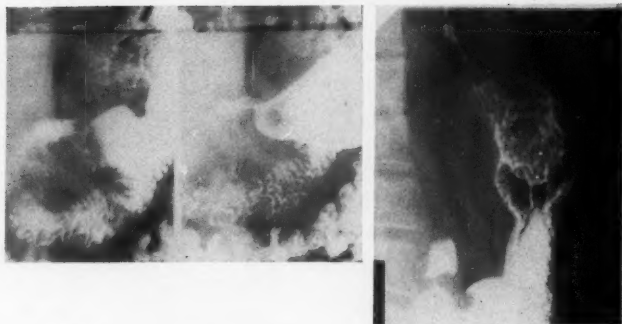


FIG. 4. Characteristic roentgenograms of gastric leiomyomata

normal than in inflammatory or malignant conditions.

4. Minimal disturbance in peristalsis.
5. Absence of niche and no incisura.
6. Tumor rarely large enough to be palpated.
7. Column of barium splits as it passes over tumor.
8. Stretching and flattening of rugae over the tumor.

All roentgenologists agree that leiomyosarcomas usually have the same roentgenographic appearance as large leiomyomas. They are, however, more likely to undergo central necrosis and excavation, so that if a tumor showing all of the signs of an intramural neoplasm exhibits, in addition, multiple fistulas extending into its substance, one may strongly suspect that it is a leiomyosarcoma.

Surgical resection of these tumors is the therapy of choice. Unless obvious metastases are present, it is extremely difficult to distinguish a leiomyosarcoma of the stomach from the benign leiomyoma, even at the time of exploration. The sarcoma is reported to occur once for every 1000 cases of gastric carcinoma. The incidence of metastases may depend largely upon the duration of the tumor—as a rule they have a tendency to metastasize late—but like other forms of gastric sarcoma, less than 50 per cent of them do metastasize.

It seems likely today that few surgeons would consider a gastric lesion categorically inoperable and refuse operation to the patient. No gastric lesion may be considered inoperable until a histologic diagnosis is made, providing, of course, distant metastases are not detectable. Upon rare occasion even this safeguard is not infallible.

Hoerr and Crile record the case history of a man aged 41 who was operated upon in 1936, 14 years before his visit to the Cleveland Clinic, a large gastric lesion found and considered inoperable. The histologic diagnosis from a biopsy specimen was "undifferentiated carcinoma." Upon reoperation in 1950 a huge leiomyosarcoma was removed. No metastases had occurred. This patient was alive, well, and working 5 years and 10 months later. This patient's prior and admitting complaint was recurring massive hemorrhage. He would undoubtedly have bled to death eventually had not a second operation been undertaken even in the face of a pre-existing diagnosis of carcinoma.

The prognosis of gastric leiomyomas is, of course, good in terms of life expectancy, so long as malignant change has not occurred within them. Dixon and Kratzer describe the patient upon whom resection had been done 23 years earlier with removal of a leiomyoma. At the second operation a leiomyosarcoma was present in the same area. Zellhoefer has reported a similar instance. Meissner describes briefly one case of leiomyosarcoma with two small leiomyomas in the muscularis immediately adjacent to the main lesion.

Jordan and his associates in their survey of the available information on the leiomyosarcomas of the stomach were interested in the prognosis of these tumors in terms of survival and regardless of the method of treatment employed. In the series collected by them, information upon 119 patients was considered sufficient: (1) operability rate, 94.1 per cent (7 patients diagnosed at necropsy); (2) resectability rate, 86.5 per cent; and (3) survival rate (5 years), 37.0 per cent.

## DUODENUM

The leiomyoma is said to be the most common benign lesion of the small intestine; when they are grouped together, about 80 per cent occur in the jejunum and ileum while some 20 per cent appear in the duodenum. Either benign or malignant tumors of the duodenum are highly uncommon. Some authors, in reviews of both clinical and necropsy material, have found a slightly higher incidence of adenomas and lipomas in the duodenum. Lest these percentages give something of a false impression of the frequency of this benign tumor in the duodenum, it must be pointed out that River in 1956 found only 32 cases reported in the medical literature. Amerson and Lumpkin in 1959 reported only 41 total cases, but according to Kelly and associates, 47 cases of malignant leiomyoma of the duodenum had been recorded to 1957. These latter authors added another case. These are most surely erroneous figures for the incidence of this tumor, for many such cases must be reposing in the files of many hospitals.

The most common symptoms of this tumor in the duodenum are weight loss, melena, anemia, abdominal pain, and abdominal mass; diarrhea, bloody diarrhea, vomiting, hematemesis, and jaundice have been reported. Both leiomyomas and leiomyosarcomas commonly have necrotic portions, central cavitation, inflammation, and fistulas connecting them to the bowel lumen. The larger tumors are more prone to show these changes; when the luminal connection is small, recurrent chills, fever, and abdominal pain may be the presenting evidence.

Leiomyosarcomas of the duodenum have a poor prognosis. Weinstein and Roberts reported in some detail the first 27 such tumors recorded. Only 7 patients were alive at the time the case reports were made. The longest survival recorded was 3 years. In Amerson and Lumpkin's series, 10 of the 41 recorded cases were alive.

In reading the case reports of patients with these malignant tumors, one is impressed that distant spread of the tumor accounts for the deaths in no more than 1 out of 4 such patients. More often the site of the tumor was such that incomplete surgical removal was all that was undertaken or permissible at operation. The pathologic and biologic characteristics of the tumors appear such that permanent arrest by

radical operation should certainly offer these patients a favorable outlook.

## JEJUNUM AND ILEUM

In the small intestine beyond the ligament of Treitz the ileum is considered the most frequent site for the benign leiomyoma and the jejunum for the malignant smooth muscle tumor. Bleeding into the bowel lumen, or occasionally from necrotic tumor into the peritoneal cavity, is the most common symptom, and it is frequently severe. Intestinal obstruction due either to intussusception or to volvulus is the other major sign of this neoplasm. A palpable mass is reported to be present in about one-third of these patients.

Of unusual interest is the occurrence of smooth muscle tumors in Meckel's diverticulum. Nygaard and Walters some 20 years ago reported upon 20 malignant tumors found in the surgical literature plus a Mayo Clinic case, of which 6 were leiomyosarcomas, and 6 others were listed as spindle cell sarcomas and very likely were tumors of smooth muscle origin.

Of practical interest is the report of Cherry and Hill of a patient in whom a leiomyoma of the jejunum simulated clinically a duodenal ulcer. They were able to collect 8 additional, similar cases from the literature. In each instance these patients had epigastric distress and melena, and in every instance in which roentgenograms had been obtained, there was described either duodenal spasm or irritability and in several instances an ulcer crater. In 4 of the 8 patients garnered from the literature there was partial or complete pain relief with food or antacids. In each instance a leiomyoma in the jejunum or ileum was found, and its removal resulted in symptomatic relief.

Probably 50 per cent of the smooth muscle tumors of small intestine are malignant and are capable of producing metastases. The liver is the most frequent site of metastatic spread and peritoneal implants are next in order of frequency. In a few reported instances involvement of lungs, thyroid, and bone has been noted. Lymph nodes are not usually involved, except by direct extension. Almost all patients with tumors which metastasized have extramural types of tumor—metastases from the intramural and submucous tumors occur, but much less frequently.

Histologically these tumors present the same lobulated, rubbery tumors as are seen elsewhere



in the tract. Conspicuous on the surface of the tumors are large vessels which represent the main blood supply to the tumor. The most important gross finding, except metastasis, suggestive of malignancy or benignancy of a tumor in this location is its size; generally, the larger tumors are malignant.

Preoperative positive diagnosis of this tumor is uncommon. It may be suggested by the presence of a palpable mass and supported by positive small bowel roentgen studies, but neither finding is specifically diagnostic (fig. 5).

Surgical treatment is recommended primarily because this form of therapy is supported by the largest experience. A wide local resection should offer a good chance of cure even in the sarcomatous group, when no obvious metastases are present. Since metastases to regional lymph nodes apparently do not occur, the removal of large mesenteric segments is unnecessary.

Despite these observations Starr and Dockerty in reviewing the Mayo Clinic figures for leiomyosarcomas of the small intestine over a 40-year period found that 50 per cent of the patients were alive at the end of 5 years. However, 3 of 13 survivors were known to have evidence of recurrent tumor—a 5-year free of disease rate of 38 per cent. These authors supported the suggestion that even tumors which were grossly inoperable should be removed as thoroughly as

possible in order to afford this characteristic opportunity for prolonged remission.

#### COLON

Smooth muscle tumors between the ileocecal valve and the rectum are pathological rarities. In 1954, MacKenzie and associates searched the medical and surgical literature and the records of the Mayo Clinic and were able to document 27 cases of leiomyoma and 10 cases of leiomyosarcoma of the colon exclusive of those in the rectum. Occasional reports of single cases have appeared since then.

The gross aspects of this tumor in the colon as well as the marked variation in tumor size are the same as seen elsewhere in the tract (fig. 6). However, approximately one-fifth of the reported tumors are encircling or constrictive, a characteristic seldom seen elsewhere in the gastrointestinal tract except in the esophagus. In general, here as elsewhere, the size of the tumor in the colon varied extremely; unlike the tumors elsewhere, the smaller ones (5 to 8 cm.) were generally the malignant variety while the larger tumors (6 to 9 cm. and larger) were more likely benign.

Since the greater number of these tumors reported has been intracolic or intraluminal in location, it seems not surprising that pain is a leading symptom, that the pain is sometimes colicky or episodic, and that perhaps 50 per cent of patients exhibit some degree of intussusception which can be seen by roentgenogram or at operation. Aside from pain, changes in bowel habits and the passage of mucous and blood were common historical findings. Bleeding is very rarely massive. Abdominal mass is the chief physical finding and about one-half of the reported patients present with this finding.

Treatment is by operative removal. There is usually no technical difficulty in applying this rule to the benign tumors, and recurrence of these is not recorded. The malignant leiomyoma differs only in its ability to invade directly adjacent structures and to implant itself on the peritoneal serosa. Regional lymph node metastases do not occur, and distant viscera have not been found to be involved. The outlook for these patients then is generally good if the sarcoma is still in its site of origin only, and complete resection is feasible. This assumption, it should be noted, is



FIG. 5. Leiomyoma of the small intestine

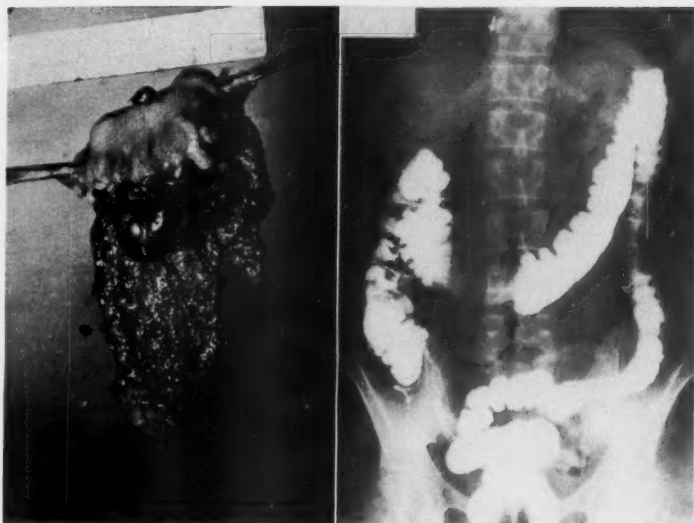


FIG. 6. Leiomyosarcoma of the transverse colon; gross specimen removed at operation

based upon very few patients, so that an accurate determination of prognosis cannot be made.

In reviewing the palliative resections reported, one is impressed with the length of survival of those patients with residual incurable tumors.

#### RECTUM

Although the rectum is uncommonly occupied by smooth muscle tumors, they are somewhat more common here than in the remainder of the colon. In 1952 Neuman reported that only 8 cases of leiomyosarcoma of the rectum had been reported. However, 2 years before, in 1950, Anderson and associates were able to collect in their own institution 10 cases of leiomyoma and 10 of leiomyosarcoma of the rectum from files dating to 1911. Bruce and Stalker in a 20-year survey collected 1 leiomyoma and 5 leiomyosarcomas from the Aberdeen, Maryland area.

The vast majority of benign lesions of the rectum are small and within reach of the examining finger. Those tumors arising in the anterior wall may arise from the muscular coats of the rectum or from the vaginal septum. They are usually asymptomatic and are detected during routine physical examination. Benign lesions affect women chiefly; malignant lesions predominate among men. Local excision is sufficient for eradication.

The malignant leiomyoma is usually the lesion

which produces the symptoms of rectal bleeding, change in bowel habits, and pain. These tumors vary greatly in size; the larger lesions are usually malignant. This lesion is a highly dangerous one. Nine of the 10 patients reported by Anderson and associates were dead of tumor, and the remaining patient was known to have a recurrence. All of the patients followed by Bruce and Stalker were dead within 1 year. For this reason any operation other than radical resection—usually a combined abdominoperineal resection—is the treatment of choice.

These tumors, like those elsewhere in the gastrointestinal tract, show varying degrees of aggressiveness. The more benign varieties commonly show a prolonged survival despite local recurrence and peritoneal sarcomatosis. In this group operations of palliation are of much value. The more malignant varieties rarely survive 2 years, and efforts at palliation are minimally rewarding.

Of particular interest with regard to the muscle tumors arising in this area is the case report by Neuman. His patient, 66 years old when seen in 1942, had a 6-cm. tumor enucleated from the anterior rectal wall. A recurrence was excised 4 years later from the same area. Both tumors were histologically benign. A second recurrence in 1949 was histologically malignant and was removed by combined abdominoperineal resection. The

TABLE 1

*Smooth muscle tumors of the gastrointestinal tract*

Location	Leiomyoma	Leiomyosarcoma
Esophagus.....	1*	1
Stomach.....	14†	4
Jejunum.....	3	2
Ileum.....	0	2
Colon.....	0	1
Rectum.....	2	0
Total tumors.....	20	10

\* Clinical diagnosis.

† Clinical diagnosis, 1; postmortem diagnosis, 4. One patient had 2 tumors.

patient was well 1 year and 9 months later. This lesion was undoubtedly one of low grade malignancy. Moreover, as in similar lesions above this level of the gastrointestinal tract, the histologic evidence of malignancy is rarely incorrect, while histologic evidence of benignancy is not always accurate. Such tumors therefore deserve the surgeon's greatest respect, and demand a full measure of his knowledge and skill in treatment.

Our experience with the smooth muscle intestinal tract tumors is not great. It has been reviewed for the past 20 years (table 1).

The presenting symptoms in each level of the tract have been those readily predicted but are not pathognomonic and do not lend themselves well to an accurate preoperative diagnosis. The 2 patients with esophageal lesions had mild to severe obstructive symptoms. Eight of the 17 patients with symptoms due to a gastric lesion were seen because of upper tract hemorrhage; 2 patients had a palpable abdominal mass and one, intractable ulcer symptoms. The remaining 3 patients had ulcer symptoms, 2 due to a duodenal ulcer and one due to a gastric ulcer, all proven at operation. Their smooth muscle tumors were each benign and possibly symptomless. One patient, in particular, in this group is of much interest because of the rapid progression of his neoplasm.

A Negro man, 32 years old, gave a history of postcibal epigastric pain. This had been present for approximately 10 months, but not until it was accompanied by hematemesis, melena, dizziness, and blurring of vision did he seek a physician. In March 1958 a proximal gastrectomy was done for a large leiomyosarcoma (figs. 7 and 8). A solitary metastasis was present in the left lobe of the liver; this was removed by left partial lobectomy early the following month. The patient returned 5 months later with dysphagia and weight loss. His roentgenogram showed recurrent tumor in the

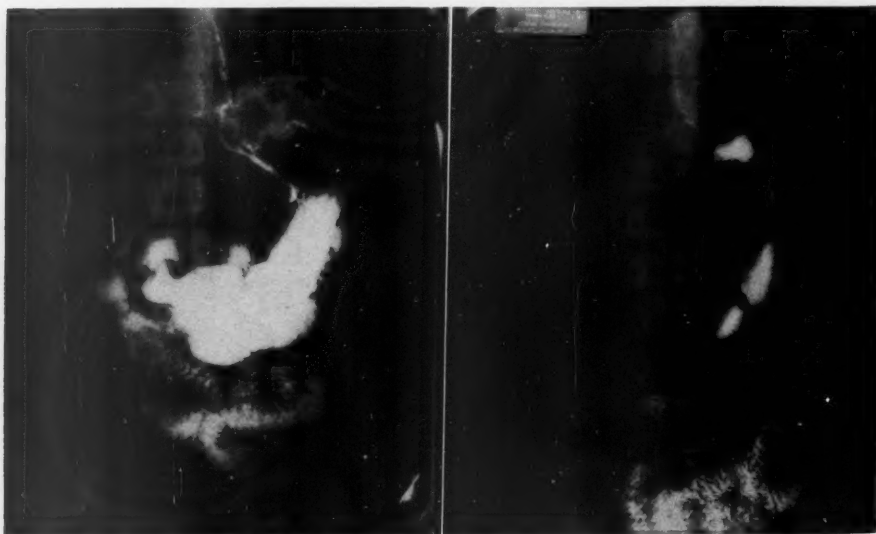


FIG. 7. Leiomyosarcoma of the stomach. A preoperative roentgenogram; B, 5-month postoperative roentgenogram.

gastric pouch. At operation there was extensive metastatic sarcoma of the peritoneal surface, lymph nodes, and liver. The patient succumbed shortly after discharge.

This acute, fulminating course is characteristic of a small group of patients with this lesion; it is more characteristic of, and probably indistinguishable clinically from the gastric carcinoma seen in young people.

Four of the 7 patients with tumors in the small intestine also presented with bleeding; in 1 patient this was massive and fatal 2 days after admission.

One patient had a 9- by 8-cm. mass in the epigastrium which upon roentgen examination showed narrowing of the transverse colon but not ulceration. This patient had only a sensation of pressure. At operation, there was one large me-



FIG. 8. Hepatic metastasis from leiomyosarcoma of the stomach

tastasis in the right lower quadrant but none in lymph nodes or other viscera.

The rectal lesions were either identified by accident or discovered because of mild anal discomfort, more suggestive of a small area of infection than of neoplasm. Both were considered benign, were removed locally, and have not recurred.

#### SUMMARY

A review of patients seen over a period of 20 years at the University of Maryland Hospital, with smooth muscle tumors of the gastrointestinal tract, reveals little that is characteristic of this tumor. In general, the roentgenologist is more often correct in his diagnosis preoperatively than is the clinician.

Of considerable interest is one patient with an esophageal malignant tumor who had marked regression of his symptoms and in whom there was a profound decrease in tumor size following irradiation. This method of therapy needs further exploration, particularly as a preoperative measure when dealing with large, bulky tumors, and as a measure of palliation.

In general, there is a small number of patients with sarcomatous gastric lesions whose clinical course is acute and fulminating; prompt and extensive resections in these instances are in order.

There is a small group of tumors which occur in the small intestine from which the symptoms of peptic ulcer derive. These must be kept in mind and looked for when the etiology of these symptoms is not found in the stomach or duodenum.

In the malignant lesions of both small intestine and colon, prolonged survival may be obtained when a vigorous surgical effort is made despite incurable spread of the tumor.

The malignant lesions of the rectum have a devastating outlook and require extensive resection by the combined abdominoperineal route.

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## INTRA-ARTERIAL RADIOISOTOPES TO TREAT CANCER

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To study the problem of how to concentrate radioisotopes into a cancer, we have investigated the introduction of large particles of radioisotopes intra-arterially. The present plan is to introduce a suspension of such particles of a suitable isotope into the artery leading to a cancer and to trap them there for their radiation effect.

Yttrium<sup>90</sup> has been selected for the first investigations, because of its uniquely suitable characteristics.<sup>4, 8-10, 14</sup> It emits 100 per cent soft beta radiation, which will penetrate soft tissue only 1 to 2 cm. It is, therefore, extremely safe for the workers to handle and for other personnel around a patient who has been treated. Its half life is 61 hr. (2.54 days), which would mean that in 18 days (the 7 half lives required to expend all practical radiation) its active life would be expended.

Different size ranges of particles have been created and used for comparison. The first was

made of particles whose largest measurement was between 30 and 60  $\mu$  (containing 3,700 particles per mg.). Later, 30 to 50  $\mu$  (4,331 particles per mg.) and others 50 to 100  $\mu$  (1,372 particles per mg.) were produced. The production has been done by the Engineering Experiment Station of Georgia Institute of Technology under the direction of Dr. Clyde Orr.

### *Method of Production of Particles*

Yttrium oxide of 99.5 per cent purity was formed into a pellet by a hydraulic press. The pellet was mounted in a solar furnace and partially fused at about 2,800° C. The fused portion was then crushed in an automatic mortar grinder and screened through a fine sieve of appropriate size to eliminate particles larger than the desired size. A smaller sized screen and air elutriation were then used to sift out the fines.

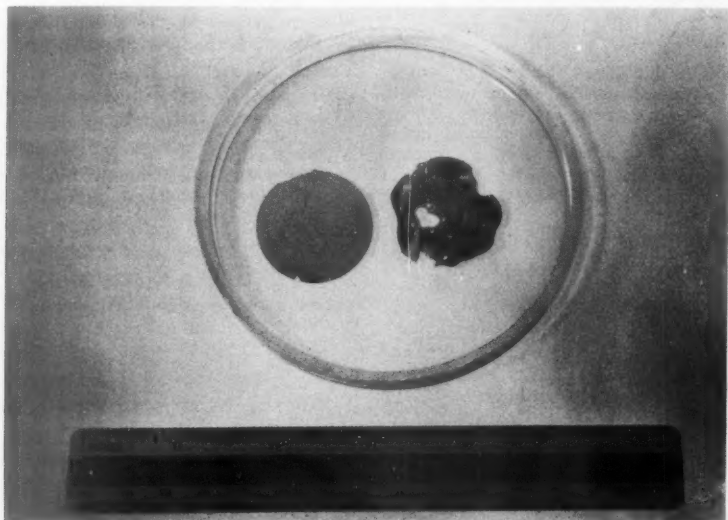


FIG. 1. Pellet of yttrium oxide before and after fusion

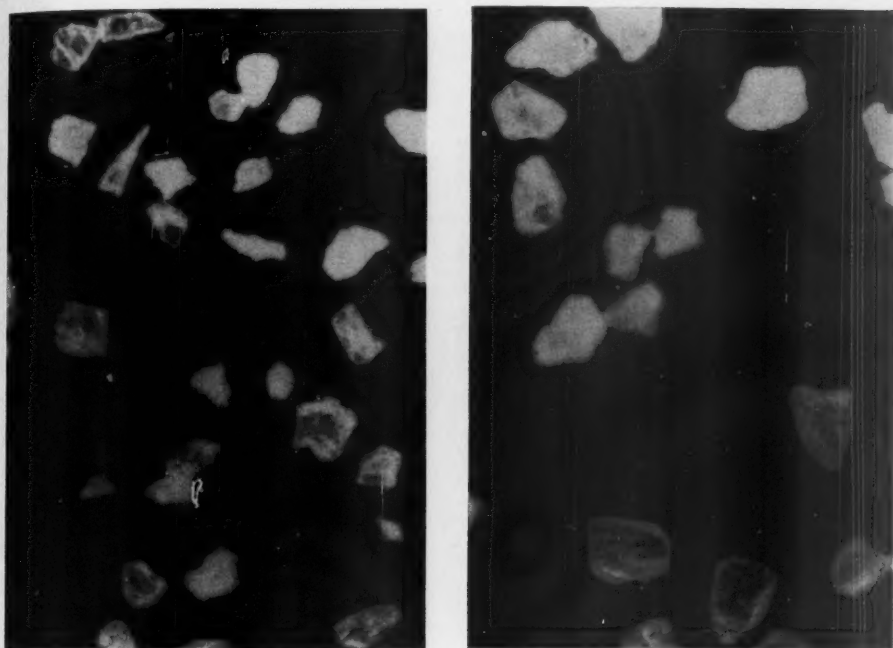


FIG. 2. Magnification of yttrium oxide particles. *Left*, 30 to 50  $\mu$ ; *right*, 50 to 100  $\mu$

*Method of Irradiation to Produce  
Yttrium<sup>90</sup> Isotopes*

The product was sent in bulk to Abbott Laboratories, Oak Ridge, Tennessee. Lots of 75 mg., 80 mg., and 100 mg. were in turn shipped to Brookhaven National Laboratory, where the reactor was deemed more appropriate. Here, each sample was irradiated in the target conveyor unit at a flux of  $8 \times 10^{12}$  neutrons per  $\text{cm}^2$  per sec. for a period of 6 days. The product was then returned to Oak Ridge, where it was assayed, separated into 10-mg. ampules, and shipped immediately to us for use. The activity varied between 0.588 and 1.61 mc. per mg.

*Method of Suspension and Injection*

Using a shielded syringe, 5 cc. of 12½ per cent dextran were injected into an ampule containing 10 mg. of yttrium<sup>90</sup>. The ampule was shaken in a mechanical shaker, its contents withdrawn into the same syringe, and designated amounts were injected into an artery.

RELATED WORK DONE BY OTHERS

Muller<sup>11</sup> first described the use of a large particle isotope, which he first injected intravenously so that it might be trapped in pulmonary capillaries to treat lung cancer. He subsequently found that he could localize the material to a single lung or one of its segments by injecting it into a catheter passed from an arm vein through the heart. Pochin<sup>12</sup> verified and extended this work.

The most suitable agent developed by Muller was Au<sup>198</sup> made from pure inactive gold chloride powder absorbed on sugar charcoal to form particles 30 to 50  $\mu$  in diameter. The gold salt was reduced to metallic gold and then exposed to the neutrons of the atomic pile. Less than 4 per cent of the radioactive gold was found to escape past the lung. In the first cases, a few gold particles 15 to 25  $\mu$  in diameter were found in the spleen. It was concluded that the particles must have a diameter of 30  $\mu$  or more to be completely filtered by the capillaries.

Pochin<sup>13</sup> from England has described by personal communication that he has used (for the same purpose of treating lung cancer) a suspen-

TABLE 1

Date	Rabbit Number	Organ Injected	Amount Injected	Readings Probe Live Animal	When Sacrificed	Readings Probe Autopsy	Auto Radiographs	Comments
10-2-59	1	Left kidney	2.94 mc. 5 mg.	No registry	29th day, very good health	No registry	No activity	No apparent damage to animal; complete recovery
10-2-59	2	Left kidney	1.47 mc. 2.5 mg.	No registry	3rd day, died	45% left kidney. Trace liver and spleen	Left kidney, strong, liver and spleen moderate	Considerable operative trauma; long anesthesia
10-2-59	3	Left kidney	5.65 mc. 9.6 mg.	No registry	2nd day, died	Not done	Left kidney moderate; liver and spleen, trace	Considerable operative trauma; long anesthesia
10-2-59	4	Right kidney	2.94 mc. 5 mg.	Very faint reading urine 2nd day	6th day, died	Strong and equal right kidney and liver. Trace lungs.	Right kidney, liver and spleen strong and equal; lungs, faint	Trauma left kidney; long anesthesia
10-2-59	5	Left kidney	1.47 mc. 2.5 mg.	Very faint reading urine 2nd day	7th day, died	Not done	Right kidney, trace, left kidney moderate; liver, spleen, strong, lung, heart, faint trace	No explanation for death
10-2-59	6	Left kidney	2.12 mc. 3.6 mg.	Not done	Died before injection finished	Not done	Left kidney, very strong; liver and spleen trace	Anesthetic death
10-2-59	7	Right kidney	2.94 mc. 5 mg.	Not done	Died before injection finished	No autopsy		Anesthetic death
10-2-59	8	Right kidney	2.94 mc. 5 mg.	No registry	30th day, very good health	No registry	No activity, so not done	No apparent damage to animal; complete recovery
12-3-59	1-b	Right thigh	5.88 mc. 10 mg.	Strong right thigh, slight chest	14th day, very good health	No registry	No activity, so not done	No apparent damage to animal; complete recovery
12-3-59	2-b	None						Anesthetic death
12-3-59	3-b	Right thigh	5.88 mc. 10 mg.	Not done	3rd day, very good health	Strong thigh muscles, lungs and liver	Right thigh, moderate lung-moderate liver and spleen, strong	No apparent damage to animal; complete recovery

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12-3-59	4-b	Right thigh	5.88 mc. 10 mg.	Strong right thigh, none elsewhere	6th day, very good health	Not done	No activity, so not done	No apparent damage to animal
12-3-59	5-b	Right thigh	2.64 mc. 5 mg.	Strong right thigh, slight chest	14th day, very good health	No registry		No apparent damage to animal
1-29-60	1-c	Right kidney	50 mg. cold					Vein occluded 1st unsatisfactory
1-29-60	2-bc	Left carotid	10 mg. cold		20th day, very good health			No apparent damage to animal
1-29-60	3-bc	Right carotid	10 mg. cold		20th day, very good health			No apparent damage to animal
2-27-60	1-d	Left kidney	8 mg. 12.88 mc.	Strong left thigh, none elsewhere	3rd day, good health	Left kidney and spleen, <i>strong</i> , right kidney and lungs, trace		No apparent damage to animal
2-27-60	2-d	Left kidney	10 mg. 16.1 mc.	Strong left kidney, none elsewhere	1 hr. after operation died	Left kidney and liver, strong, lungs and spleen, slight	Left kidney, strong, liver and lung, moderate spleen and right kidney, faint	Anesthetic death
2-27-60	3-d	Left thigh and kidney	10 mg. 16.1 mc.	Strong left thigh, none elsewhere	1 hr. after operation died	Left thigh and liver strong, lungs and spleen slight	Left kidney, thigh, liver and lung, strong, right kidney and spleen, moderate	Postoperative hemorrhage
2-27-60	4-d	Left thigh	10 mg. 16.1 mc.	Strong left thigh, <i>faint</i> trace urine, none elsewhere	4th day, very good health	Not done	Thigh, liver and spleen, strong, lung, moderate, kidney, trace	No apparent damage to animal
2-27-60	5-d	Right carotid	5 mg. 8.05 mc.	Strong right head, trace left head, trace chest	4th day, very good health	Not done	Liver and spleen, strong, brain, none, lung, moderate, kidneys, trace	No apparent damage to animal
2-27-60	6-d	Right carotid	5 mg. 8.05 mc.	Strong right head, trace left head, trace chest, none elsewhere	4th day, very good health	Not done	Liver, spleen, lung, strong, kidneys, trace, brain, none	No apparent damage to animal





FIG. 3. Rabbit no. 6. Left upper density is kidney that was injected. Right lower density is an artifact where no tissue was placed. Other organs did not register sufficiently to show on this print.



FIG. 4. Although there is considerable radiation in other tissues, there is much more in the left kidney after injecting the left renal artery.

sion of yttrium<sup>90</sup> oxide. Doses up to 50 mc. of yttrium<sup>90</sup> have been given intravenously without detectable whole body effect.

Cook<sup>1</sup> from Harwell, England, has by personal communication described his exact technique for



FIG. 5. Four days after injection in the left femoral artery, the thigh muscles still contain a great deal of radioactive material. The rabbit was in good health when sacrificed.



FIG. 6. Four days after the left carotid artery was injected, there is no evidence of activity in the brain. The rabbit was in good health.

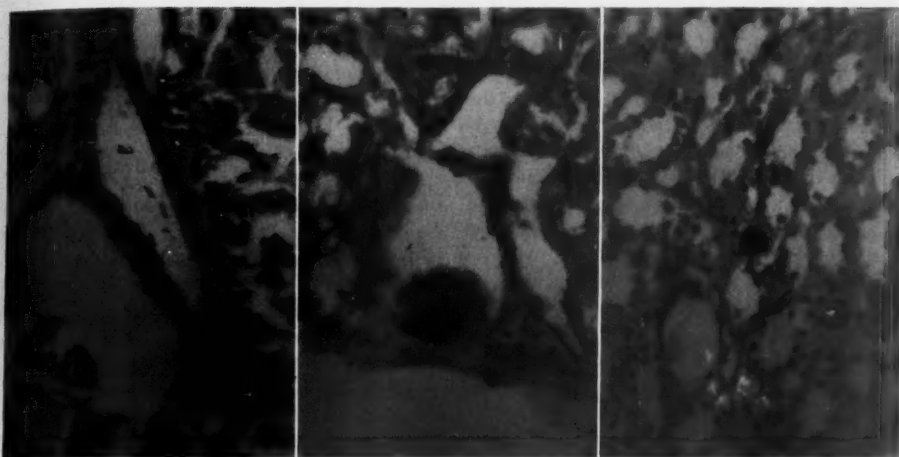


Fig. 7. These photomicrographs of kidney sections show various sized particles "trapped" in various sizes of small blood vessels in different locations throughout the kidney. No apparent mechanical or circulation damage has been produced.

manufacture of yttrium<sup>90</sup> oxide in particles sized 30 to 50  $\mu$ . The Engineering Experiment Station of the Georgia Institute of Technology modified this method to that described above to produce particles of specified size.

#### ANIMAL WORK

The rabbit has been used for our initial work. Twenty-two rabbits have had varying quantities of suspensions of large particles of yttrium<sup>90</sup> injected into several different arteries. The renal artery, femoral artery, and carotid arteries have each been used. The descriptions of the injections and the observations made thereafter are tabulated in the accompanying table.

The following general observations can be made: (1) There seem to be from 40 to 70 per cent of the particles trapped in the kidney or thigh muscles when suspensions of yttrium<sup>90</sup> oxide are injected into a renal artery or into a femoral artery. (2) The spill-over increases as time goes by. (3) About 10 to 25 per cent of the amount spilled past the organ injected is trapped in the lungs. The rest of it goes to the liver and spleen. (4) The isotopes apparently do not harm the brain if they spill past the organ injected or if they are introduced directly into the carotid artery. In the latter case, there was almost no trapping in the brain. (5) There was no area of necrosis produced at any place by capillary em-

bolization of the particles. (6) There was some apparent radiation effect observed in some kidney sections, seen occasionally as perivascular lymphocytic infiltrations. (7) Such intra-arterial injections of large particles of yttrium<sup>90</sup> seem safe.

#### SUGGESTED APPLICATIONS FOR PATIENTS HAVING CANCER

Where there is a cancer whose arterial supply can be localized, appropriate quantities of such suspension of large particles of yttrium<sup>90</sup> may be injected intra-arterially to irradiate the cancer. This may be used independently or in conjunction with chemotherapy<sup>2, 3, 5-7, 10, 15</sup> for synergism of chemotherapy and radiation effects. The chemotherapy may be given intravenously, intra-arterially, or by isolation perfusion methods.

The following sites are particularly suggested as being applicable: extremity, pelvis, lung, oral cavity, and abdomen. General abdominal disease with large liver metastases would seem especially suitable, since the spill-over has been found to be so concentrated in the liver. Methods of catheterizing the celiac artery for this purpose are being investigated.

#### SUMMARY

A method of producing particles of yttrium<sup>90</sup> radioactive isotopes in sizes slightly larger than capillaries has been developed.

These particles have been suspended in 12½ per cent dextran and injected in various arteries of 22 rabbits.

There have been from 40 to 70 per cent of the particles trapped in the kidney or the thigh muscles when renal or femoral artery was injected.

The spill-over is trapped in small amounts in the lungs and in greater amounts in the liver and spleen. The spill-over seems greater as time goes by.

No harm was done when particles were injected directly in the carotid artery.

No necrosis was produced at any site by capillary or artery occlusion.

Applications of this method to treat human cancer are suggested.

*Acknowledgment.* Appreciation and credit are given to: the Engineering Experiment Station of Georgia Institute of Technology for producing and providing the appropriate sizes of particles of yttrium, Abbott Laboratories for converting the yttrium into radioactive isotopes, Piedmont Hospital, Atlanta, Georgia, for providing the laboratory facilities, personnel, and equipment for this work, and Dr. Rose Vincenzi for processing and interpreting the histological sections.

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## SUBTOTAL GASTRECTOMY FOR BENIGN GASTRODUODENAL ULCERATION IN THE PATIENT OVER SIXTY

WILLIAM T. WILLIAMS, M.D.

Dunedin, Florida

The usual description of peptic ulcer classically lists the condition as a disease of relatively young or middle-aged men in some way associated with the stress of that particularly demanding period of life. The impression is gained that following appropriate medical therapy, in the majority of patients, the condition is controlled, and when the individual reaches the latter third of his life there is no indication that he previously suffered from the disease. There is little to indicate that the condition may persist into the latter years of life despite appropriate medical therapy or that the condition may first make its appearance during this time.

We would not take exception to the fact that peptic ulcer occurs primarily during the middle years of life or to the efficacy of medical therapy. We would emphasize that the ulcer may frequently persist in a smoldering fashion until the latter years of life or may first develop during this same period. We are afforded the opportunity of making observations of elderly patients by the selection of this general area for retirement by large numbers of people. It has been estimated that 60 per cent of the residents of this county on the west coast of Florida are 60 years of age or older. Thus at the Mease Clinic it is the rule rather than the exception to care for the patient over 60 years of age. It is the purpose of this report to trace the peptic ulcer from its beginning until gastrectomy in patients 60 years or older; to review the indications for surgery, the associated pathologic conditions, and the complications; to determine what problems if any are unique to this group, and in retrospect, to see if a change in management would have benefited the group or the individual.

### CLINICAL MATERIAL

During a 5-year period from 1953 to 1959 distal subtotal gastrectomy was performed as the only operative procedure on 37 patients 60 years of age or over for benign peptic ulcer. There were no marginal ulcers in this group. The amount of stomach resected ranged from 60 per cent to 80

per cent. Gastrointestinal continuity was re-established by gastrojejunostomy in all except one case with the reconstitution being about equally divided between an anterior Hofmeister and a retrocolic Polya. In a single case a gastroduodenostomy was utilized. It was not necessary to stage any of the procedures nor were catheter duodenostomy, excision of pyloric mucosa, or related procedures performed. Of the 37 patients, 5 were women and 32, men.

### Age

About one-third of the group was between 60 and 64 years (table 1) and the remaining two-thirds were 65 years of age or older. The eldest patient was 81 years old.

### Symptoms

Slightly more than one-half of the patients had experienced symptoms for 2 years or less (table 2), and the remainder had endured symptoms from 3 to 30 years. Three patients had experienced no symptoms before those for which they were gastrectomized. The symptom-producing ulcers were located in the duodenum (table 3) in 24 cases, in the stomach in 9, and 4 patients had both gastric and duodenal ulcers.

The symptoms, complications, or sequelae of peptic ulcer for which gastrectomy was performed were divided into 4 categories: bleeding, obstruction, intractability, and serious question of malignancy. Perforation was not an indication for gastrectomy in this series. More often than not the patient had symptoms or findings which placed him in more than one of the above categories. Table 4 shows the indications for surgery and the number in each category relative to the length of symptoms. Since patients were frequently entered in more than one category the number far exceeds the 37 patients in the series.

For illustrative purposes, the bleeding category was subdivided into 4 classes (table 5): (1) one-plus hemorrhage—coffee ground emesis and/or tarry stools without hypotensive symptoms or findings, (2) two-plus hemorrhage—vomiting of

bright blood, tarry stools, hypotension, and pallor, all responding promptly and permanently to medical management and relatively small amounts of blood, (3) three-plus hemorrhage—alarming, massive hematemesis and tarry stools with frank shock requiring large quantities of

blood over a relatively long period of time and when there was doubt as to the ability of medical management to control the problem, and (4) four-plus hemorrhage—same in extent as the three-plus category except that medical measures failed and emergency gastrectomy was necessary.

TABLE 1  
*Age of patients*

Age	Percentage	Number
60-64	32.4	12
65-69	29.7	11
70-74	24.3	9
75-79	10.8	4
80-	2.7	1

TABLE 2  
*Length of symptoms*

Length of Symptoms	Percentage	Number
None	8.1	3
1 to 6 mo.	29.7	11
7 mo. to 2 yr.	13.5	5
3 to 10 yr.	21.6	8
11 to 20 yr.	16.2	6
21 to 30 yr.	10.8	4

TABLE 3  
*Ulcer location*

Ulcer Location	Number
Duodenal.....	24
Gastric.....	9
Duodenal and gastric.....	4

TABLE 4  
*Indications for gastrectomy as correlated with length of symptoms*

No. of Patients	Length of Symptoms	Indications							
		Hemorrhage		Obstruction		Intractability		Malignancy ?	
		%	no.	%	no.	%	no.	%	no.
3	None	67	2	67	2	0	0	33	1
11	1 to 6 mo.	64	7	0	0	46	5	36	4
5	7 mo. to 2 yr.	40	2	0	0	80	4	20	1
8	3 to 10 yr.	50	4	25	2	50	4	25	2
6	11 to 20 yr.	67	4	67	4	67	4	0	0
4	21 to 30 yr.	75	3	25	1	25	1	0	0

#### *Associated Conditions*

As would be expected in a group of this age the complaints referable to the peptic ulcer were not always the only complaints nor was the peptic ulcer the sole pathologic entity. There were 29 significant pathologic conditions in 22 of the patients. These associated conditions have been classified as shown in table 6.

#### *Complications*

A total of 16 complications occurred in 14 patients. Table 7 shows the breakdown into cardiopulmonary, abdominal, and "other" categories. Table 8 shows which complications occurred with which associated condition.

#### *Mortalities*

There were 4 deaths in this group of 37 patients, giving a mortality rate of 10.8 per cent. A summary of the deaths is outlined in table 9.

#### DISCUSSION

The only operative procedure employed for peptic ulcer during the interval of this series was distal subtotal gastrectomy. This does not imply that other operative procedures have not or will not be utilized as the occasion demands. Gastroenterostomy and vagotomy should receive consideration when duodenal stump problems can be anticipated. The extremely bad risk patient with unrelenting obstruction as the indication for



TABLE 5

## Severity of hemorrhage

Severity of Hemorrhage	No. of Patients
1+	7
2+	3
3+	10
4+	2

TABLE 6

## Pathologic conditions associated with peptic ulcer in 22 patients

	No. of Cases
Cardiopulmonary	
Arteriosclerotic heart disease.....	9
Previous myocardial infarct.....	4
Rheumatic heart disease.....	1
Aneurysm ascending aorta.....	1
Emphysema, severe.....	4
Bronchiectasis, severe.....	1
Renal	
Uremia.....	5
Pyelonephritis.....	1
Other	
Chronic alcoholism.....	2
Hypoproteinemia.....	1
Total.....	29

operation might better be handled with gastroenterostomy alone. It is realized that when gastroenterostomy is performed, the problem of marginal ulcer immediately arises. However, it has been the experience with large series of gastroenterostomies that approximately 60 per cent of the individuals remained symptom-free and that when marginal ulcers do develop they usually require from 3 to 5 years to make their appearance. It might well be that in the extremely bad risk individual the life expectancy might be somewhat less than the 3 to 5 years required for the development of the marginal ulcer. The situation is somewhat analogous to that confronting the surgeon with a bad risk individual and acute cholecystitis—whether to proceed with a less desirable cystostomy or perform the ideal operation of cholecystectomy. Certainly the choice is difficult at times but it must be remembered that the aim is to afford relief to a living patient rather

TABLE 7

## Complications occurring in 14 patients

	No. of Cases
Cardiopulmonary	
Pulmonary embolus.....	2
Myocardial infarction.....	2
Myocardial failure.....	1
Pneumonitis.....	1
Abdominal	
Superficial wound separation.....	3
Complete wound separation of post-operative hernia.....	2
Obstruction of stoma.....	1
Duodenal stump leak.....	1
Protracted ileus.....	1
Other	
Parotitis.....	1
Pyelonephritis.....	1
Total.....	16

than employ a more hazardous procedure which might be considered more ideal.

Despite the renewed interest in gastroduodenostomy during the latter years of this series it was considered applicable in only one case by the author. The years of scarring and penetration in the majority of these elderly ulcers make the duodenum completely unsuitable for mobilization and anastomosis. In the single case in which gastroduodenostomy was employed the patient had experienced symptoms for only 2 weeks and was hospitalized for massive hemorrhage.

With a few notable exceptions the amount of stomach usually resected by the majority of surgeons is said to be around 75 per cent. In this age group the author prefers to limit the amount of stomach removed to 60 per cent. The postoperative result has been gratifying without exception in that there has been weight gain and a notable lack of dumping and postprandial discomfort. To date there has been no indication of the development of marginal ulcer in any of the group although admittedly the follow-up period is short in many instances.

Cutler<sup>1</sup> in reviewing 3,049 cases of peptic ulcer recorded during a 16-year period noted that 430 of the patients were 60 years of age or over. The average duration of symptoms was 11 years, and he observed that relatively few ulcers developed for the first time after the age of 60. The average

TABLE 8

*Associated conditions correlated with complications*

Associated Conditions	Complications											
	Pneu- monitis	Myo- cardial failure	Myo- cardial infarc- tion	Pulmo- nary embolus	Super- ficial wound separa- tion	Com- plete wound separa- tion	Ob- struc- tion stoma	Stump leak	Pro- tracted ileus	Para- toxis	Pyelo- nephri- tis	None
	1	1	2	2	3	2	1	1	1	1	1	23
Arteriosclerotic heart disease, 9	1	1*	2*	1	2						1	2
Previous myocardial infarction, 4	1											3
Rheumatic heart disease, 1						1						
Aneurysm ascending aorta, 1												1
Emphysema, severe, 4					2				1			1
Bronchiectasis, severe, 1									1			
Uremia, 5					1			1*				3
Pyelonephritis, 1												1
Chronic alcoholism, 2												2
Hypoproteinemia, 1												1
None, 15				1*		1	1					12

\* = Single fatality.

TABLE 9

*Analysis of deaths*

Age	Ulcer Duration	Indication	Associated Condition	Cause of Death	Postoperative Day Death Occurred
64	28	Intractability	Arteriosclerotic heart disease	Myocardial failure	4th
72	4	Obstruction	Uremia	Duodenal stump leak and peritonitis	30th
71	25	Hemorrhage, 4+	Arteriosclerotic heart disease	Myocardial infarction	Day of operation
70	29	Hemorrhage, 3+	None	Pulmonary embolus	9th

duration of symptoms in this series was 7.7 years and unlike Cutler's group about one-third of the patients developed some manifestation of a peptic ulcer after 60 years of age.

As mentioned previously, 8 per cent of this group had no symptoms before the abrupt onset of peptic ulcer manifestations which required operative intervention. Bleeding and obstruction were the initial symptoms in  $\frac{2}{3}$  of this small group, which was similar to Cutler's observation.

Even more impressive were the years of discomfort, diet, medication, and restrictions endured by so many of the patients in this series: 22 per cent for 3 to 10 years, 16 per cent for 11 to 20 years, and 11 per cent for 21 to 30 years. Oddly enough only 5 of the 18 gastrectomies in the longstanding ulcer group were performed primarily for intractability, whereas 6 were done primarily for intractability in the group of 19 patients who had experienced symptoms for 2

years or less. The impression was gained that those individuals with a longstanding ulcer history had become accustomed to the many restrictions imposed by their disease. It was felt that perhaps older people were somewhat less tolerant to recently developed unpleasant situations than were the young. In any event it was not unusual for the recent ulcer group to complain bitterly and unremittingly about the discomfort of their disease until in the final analysis an equal percentage of gastrectomies were performed for intractability in both the relatively short term and the long term ulcer groups.

Obstruction did not constitute an indication for gastrectomy in any of the patients who had experienced symptoms for less than 3 years. It is true that the gastrointestinal x-rays demonstrated obstruction in the acute ulcer group who had had no previous symptoms before admission, but this obstruction would undoubtedly have subsided had it not been necessary to perform gastrectomy for hemorrhage. In the group who had experienced symptoms for 3 to 10 years obstruction accounted for 25 per cent of the gastrectomies. Obstruction as an indication for surgery played the most prominent role, sometimes combined with intractability in those patients who had symptoms for 11 to 20 years, accounting for 67 per cent of gastrectomies in this group. Our experience is the same as others who have reported that obstruction occurring in these elderly patients with longstanding ulcers rarely responds to medical therapy. These people are usually thin, underweight, vomit with increasing frequency, and in turn experience further weight loss. Their preoperative preparation requires attention to detail and time. In this group with unusually serious associated disease, oral preparation is frequently not possible, and the associated conditions suffer as a consequence. It is here that an operative procedure of lesser magnitude than gastrectomy might be more frequently indicated.

The question of malignancy in a gastric ulcer as an indication for gastrectomy did not occur in any patient having symptoms over 10 years. Patients in whom a question of malignancy served as the most frequent indication were those who had symptoms for 1 to 6 months. Here, 36 per cent had gastrectomies following medical management and failure of the gastric ulcer to heal.

Hemorrhage was by far the most frequent in-

dication for operation. As mentioned previously hemorrhage was classified in four categories. The one-plus category was not an indication for gastrectomy. The two-plus hemorrhage category was not an indication unless the patient was under a strictly supervised medical regimen at the time of bleeding; this occurred in one case. There was actually little difference in the amount of hemorrhage between the three-plus and the four-plus categories; both were alarming. In the three-plus group, hemorrhage ceased after an interval and the surgeon was able to select a time for gastrectomy after suitable preparation. In the four-plus category the bleeding selected the time for gastrectomy. This is a matter of great importance because it has been shown by Parsons<sup>2</sup> and others that these elderly people do not tolerate emergency surgery at all well. Even though the initial insult is of approximately the same magnitude, if an unhurried period of precise blood component replacement can be allowed, the mortality can be reduced. This period also allows for recovery from the stress imposed by hemorrhage; it allows for equilibration of other body functions; and of utmost importance, it allows for the intelligent correction or support of associated pathologic conditions present in so many of these people. The asthmatic, the emphysematous patient or the individual with cardiac failure faces the operative procedure with a much brighter outlook if these conditions are considered to be under optimal control at the time of surgery.

We have employed blood volume determinations in these people to guide in the qualitative and quantitative replacement of the blood components because we have been unable to estimate the cell mass and plasma mass by the use of the usually employed hemoglobin, hematocrit, and red blood cell count.<sup>3</sup> Even after the prompt quantitative replacement of blood during the actively bleeding phase we have been disturbed to find occasionally either the plasma volume or the red blood cell volume completely out of line as determined by blood volume studies. Also, we consider it important to restore the blood volume slowly unless, of course, the individual is bleeding at the time. These elderly people, especially with cardiopulmonary complications, do not tolerate the extra load imposed upon the heart by too rapid transfusion. Usually transfusion is limited to 250 cc. of packed cells or 500

cc. of whole blood in a 24-hour period. In those patients in whom bleeding constituted the indication for gastrectomy, an average period of 12 days was spent in preoperative preparation. It might be added that the internist and surgeon work hand in hand in managing the patient with gastrointestinal hemorrhage.

Hemorrhage served as the indication for gastrectomy in 13 patients. Two of these patients failed to cease hemorrhaging under medical management and emergency gastrectomy was necessary. Ten patients hemorrhaged as much initially and for varying periods of time as the 2 patients mentioned above but did stop bleeding. While they were not done as purely elective procedures, the surgeon was able to select the time of operation. One patient bled moderately while on a strict medical regimen and was operated upon for this reason.

Since the percentage of true emergency operations for hemorrhage is much lower in this series than in the majority of others, the next question to arise would naturally concern the number of people who hemorrhaged to death from a peptic ulcer without "benefit" of surgery. During this same 5-year period only 2 people expired as a result of hemorrhage from a proved or presumed peptic ulcer.

*Case 1* (Hospital #22591). An 86-year-old white woman had been bedridden with the exception of trips to the table and to the bathroom for the past several years. During the preceding week she had been too faint and dizzy to leave the bed for even these brief periods. The patient had several tarry stools following admission and expired while receiving blood transfusions 5 hours after admission. The hemoglobin was reported as 4.3 gm. per cent.

*Case 2* (Hospital #21792). A 72-year-old white man was admitted with a history of passing tarry stools and epigastric distress relieved by milk. An original hemoglobin of 6.3 gm. was reported, and the patient received 1,000 cc. of blood on the day of admission. In addition to the bleeding peptic ulcer the patient was under active treatment for arteriosclerotic heart disease. Two days following admission the patient developed pulmonary edema and died despite all measures to control the condition.

There appears to be no relationship between the length of peptic ulcer history and hemorrhage. A large percentage of those without symptoms bled initially and a similar percentage of those

with symptoms dating 20 to 30 years also had bleeding as an indication for gastrectomy.

It should be mentioned that the group classified as having arteriosclerotic heart disease were all under active treatment for this condition with digitalis preparations, diuretics, etc. There were 9 in this category. Four patients had suffered from previous myocardial infarctions, and these patients technically should be considered under the arteriosclerotic heart disease group. Although a number of these citizens had emphysema, 4 of the group were experiencing real difficulty and were being actively treated for the condition. The uremia classification was based on a significantly elevated blood urea nitrogen as a result of longstanding prostatic obstruction.

When the associated conditions are plotted against the complications it quickly becomes apparent that the elderly patient with arteriosclerotic heart disease is likely to experience difficulty in his postoperative course. The difficulty is likely to be serious and in the cardiopulmonary system. Of 9 patients with arteriosclerotic heart disease, 5 developed cardiopulmonary complications, 2 of which were fatal. The group that had suffered from previous myocardial infarctions got along well with only one episode of pneumonitis which cleared rapidly. The emphysema patients, perhaps as a result of incessant coughing, had minor wound difficulties in 50 per cent of the cases. In this statistically insignificant series there was a 20 per cent complication rate in those patients without associated conditions and a rate almost twice that, 36 per cent, in the people with associated pathology.

The anesthetic and operative management of these people, especially the ones with arteriosclerotic heart disease and previous myocardial infarctions, requires the utmost delicacy. A heart laboring under conditions of a marginal blood supply does not tolerate hypotension or shock. This is the prime reason why we believe it essential to enter the operative procedure with an absolutely normal blood volume. Should unexpected blood loss occur the chances of hypotension or shock developing are much greater if the blood volume is low initially than if it is normal.

Postoperatively every attempt is made to ambulate the patient on the first postoperative day. Several years ago the author began to omit nasogastric suction as a part of the postoperative management of small and large intestinal resec-

tions. Later, when patients who had had gastrectomy performed removed their gastric tubes prematurely, and were hesitant about having them replaced, these too were left out with no demonstrable ill effects. During the last 3 years the author's gastrectomy patients have been spared nasogastric tubes as part of their postoperative management. Their oral intake is restricted to an occasional moistening of the lips until bowel sounds appear or flatus is expelled. There has been a noticeable lack of respiratory complications which are usually associated with nasogastric tubes in the elderly patient. In addition the patient is free to move about and is more easily ambulated early during his postoperative course. There have been no duodenal stump or anastomotic leaks and only occasional vomiting on the part of the patient.

In the discussion concerning the mortalities it might be well to consider the condition responsible for death.

*Case 1, Myocardial failure.* This patient insisted that he could no longer tolerate the discomfort and restrictions imposed by his peptic ulcer and medical regimen. His heart disease was apparently as well controlled as were a number of others in the series who survived the operative procedure. However, the stress of the surgery was enough to cause him to expire in myocardial failure despite all medical measures to the contrary. If there is a lesson to be learned here, it may concern the question of intractability as an indication for gastrectomy in a patient with an extremely serious associated pathologic condition. However, this problem is not likely to be solved except in retrospect in the patient who emphatically states that he does not care to continue his life under the circumstances imposed by his peptic ulcer.

*Case 2, Duodenal stump leak.* The operative note in this case showed that the surgeon had difficulty with duodenal stump closure, and this case represents the only fatal technical error occurring in this series. In retrospect, this is an instance that would have been better handled by gastroenterostomy with or without vagotomy.

*Case 3, Myocardial infarction.* This individual had survived the resection of a ruptured aortic abdominal aneurysm 8 months previously and was being actively treated for arteriosclerotic heart disease and hypertension. In addition, he was 1 of the 2 individuals who had an emergency gastrectomy performed for hemorrhage. He had several hypotensive episodes while attempts were

made to control his bleeding medically and also had one episode of hypotension during surgery. However, he survived the operative procedure and was awake and alert 6 hours postoperatively with a normal blood pressure when he suddenly expired from a myocardial infarction. Undoubtedly the repeated periods of hypotension were major factors in the myocardial infarction.

*Case 4, Pulmonary embolus.* There were no signs or symptoms of venous thrombosis until the sudden appearance of a fatal pulmonary embolus. The reader is referred to Coon and Collers' recent extensive study of thromboembolism and pulmonary embolism. It is disturbing when dealing with patients of this age to note the linear increase in the incidence of pulmonary embolism with age. Because of the high incidence of associated cardiac abnormalities in this group it is equally disturbing to note the greatly increased incidence of pulmonary embolism associated with heart disease. If prophylactic anticoagulant therapy is to be employed, this would be a logical select group for its use.

#### SUMMARY

In this communication we have attempted to deal with the over-all subject of subtotal gastrectomy performed for peptic ulcers in patients over sixty years of age. A group of 37 patients in this category, operated upon during a 5-year period at the Mease Hospital, has served as the reference point for the discussion.

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## Editorial

### A CRITIQUE OF DR. FIROR'S EDITORIAL ON BREAST CANCER

As a surgeon with considerable experience with radical mastectomy and recently with simpler operations in the treatment of breast cancer I feel compelled to challenge Dr. Firor's editorial published in the January 1960 issue of *The American Surgeon*. My criticism is based on: (1) Dr. Firor's failure to document his assertions. (2) His personal attack on the motives of competent surgeons who employ simple mastectomy. I do not intend to argue the superiority of one or another method of treatment, but to point out that the issue is by no means settled and that clinical investigation of the results of various methods should not be discouraged.

Dr. Firor states that from the time appendectomy was first practiced until the discovery of sulfanilamide, the death rate from appendicitis rose steadily until it reached 36 per 100,000. He then states that during the past decades we have witnessed a similar deterioration in the treatment of mammary carcinoma. If there are statistics that bear out Dr. Firor's implication that the death rate per 100,000 from cancer of the breast has increased in the past 10 years, I have not been able to find them. The most remarkable feature of the natural history of breast cancer has been the constancy of its death rate, not only in the United States, but in all countries in which death rates are reported. McKinnon<sup>1, 2</sup> has shown that these death rates appear to be unaltered, either by public education or availability of the most modern surgical and radiologic facilities.

Dr. Firor then states that amongst "competent surgeons" one of the causes for poor results following radical mastectomy is "whittling down the real Halsted procedure. . . ." No data are given in support of this statement, and to my knowledge none exist. Meyer and Smith<sup>3, 5</sup> report that the survival rate of patients operated upon for mammary carcinoma is not affected by the qualifications of the surgeon. I know of no report of a controlled series of cases in which modifications of Halsted's radical mastectomy have been shown to be less effective than the operation originally described. It would be strange if any operation devised more than half

a century ago were still ideal. In most fields we have seen progress; why not in the treatment of cancer of the breast?

It is surely true, as Dr. Firor points out, that a radical mastectomy is less time-consuming and less expensive than is simple mastectomy and radiation. This argument (even if it were valid) implies that all patients subjected to simple mastectomy must have radiation therapy, a point that is by no means established. Paterson and Russell's<sup>4</sup> studies in Manchester showed that radiation therapy after radical mastectomy contributed nothing to the survival rate of patients whose axillary nodes were involved. His studies also suggested that in cancers without nodal involvement, better results were obtained when the patients were not treated by radiation.

To add to the confusion, the few studies in which the stage of disease was comparable and in which the patients had been treated during the same period of time by different methods,<sup>3, 5-7</sup> suggest a small, but definite superiority in the survival rate of patients who underwent simple operations as compared to those treated by radical ones. In my experience with simple mastectomy, which is now of only 5 years' duration, the increased survival rate after simple operations as compared to radical was evident in the favorable cancers without preoperative evidence of axillary spread. Most of these received no radiation therapy. When nodes were clinically involved, there was little or no difference in survival, regardless of the treatment employed.

It is now accepted that cancer cells are often distributed widely in the circulation and that the host's resistance appears to determine whether or not the circulating cells will implant and grow as metastases. Yet Dr. Firor states categorically, "The hard and deplorable fact is that many women with a mammary carcinoma which is curable by a Halsted mastectomy are denied their only chance of living by the substitution of a simple mastectomy and irradiation." In some cases this may be true, but in others it is possible that radical mastectomy may disseminate cancers that would not have metasta-

sized after simpler operations. At present we cannot distinguish between the types of breast cancer that may be helped and those that may be harmed by radical operations.

Until we have learned how to recognize and to treat appropriately each of the various types of breast cancer, we should encourage competent surgeons to study new methods, ultraradical, ultraconservative, and combinations of these with other agents. Certainly the classic Halsted operation, which is neither radical nor conservative, is doomed to be partly replaced, either by more extensive regional lymphadenectomies or by simpler procedures. Few concepts in science or surgery are forever static. There is no reason why our concepts of breast surgery should be forever the same.

Dr. Firor, addressing himself to "competent surgeons," said that poor results are due to modifying the real Halsted procedure "... either from ignorance, hurry, or sheer laziness." It is hard to see how a competent surgeon could be accused of being ignorant of a technique so widely taught as the Halsted radical mastectomy. It is equally difficult for me to believe that "hurry" or "sheer laziness" motivates competent surgeons to perform operations that they recognize as inadequate. Such statements, unless documented by careful psychologic study of the motives of "competent surgeons," have the ring of emotionalism.

This comment is not written in defense of simple mastectomy nor of radiation therapy and it is not an attack on the Halsted radical mastectomy. These comments are written in defense of the "competent surgeons" whose motives Dr. Firor has attacked. It is also written in defense

of the right of competent surgeons to engage in clinical research.

If surgeons wish to attack simple mastectomy and prove that it is not so good as the radical operation, let them document their articles with convincing proof. Until this has been presented, there is no need to criticize the motives of surgeons who perform simple mastectomies.

Dr. Firor, as a respected surgeon, should not try to stop the clock at the year 1900. He should do all he can to encourage clinical investigation.

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